COMPLIMENTS OF

DANIEL J. MORRELL,

JOHNSTOWN, PA.

THE

IRON AND STEEL EXHIBITS

AT THE

UNIVERSAL EXPOSITION OF 1878,

AT PARIS.

A REPORT TO THE SECRETARY OF STATE

BY

DANIEL J. MORRELL,

UNITED STATES COMMISSIONER TO THE UNIVERSAL EXPOSITION OF 1878.

PRINTED BY PERMISSION OF THE SECRETARY.

PHILADELPHIA:
THE AMERICAN IRON AND STEEL ASSOCIATION,
No. 265 SOUTH FOURTH STREET.
1879.

PRINTED BY
ALLEN, LANE & SCOTT,
233 South Fifth Street,
PHILADELPHIA.

THE

IRON AND STEEL EXHIBITS AT PARIS.

HON. WILLIAM M. EVARTS,
Secretary of State, Washington, D. C.

SIR:—I have the honor to submit for your consideration the following report on the exhibits of iron and steel which were made at the Universal Exposition of 1878, at Paris, and upon the condition of the iron and steel industries of the world at the present time. In the collection of the historical and statistical information contained in it I have had the valuable assistance of Mr. James M. Swank, the Secretary of the American Iron and Steel Association, and this assistance I thankfully acknowledge.

I am, sir, very respectfully, your obedient servant,

D. J. MORRELL,
United States Commissioner to the Universal Exposition of 1878.

JOHNSTOWN, PA., February 28, 1879.

REPORT.

THE Joint Resolution of Congress, approved December 15, 1877, in relation to the Universal Exposition of 1878, at Paris, provided for the appointment by the President of twenty Commissioners additional to the Commissioner-General, and on the 12th day of February, 1878, I had the honor to be appointed one of these Commissioners. The Exposition was opened to the public on the 1st day of May, and was closed on the 10th day of November. A large portion of the intervening time I spent at Paris or in visiting such industrial centres as would afford needed information in the preparation of this report. By arrangement with the Commissioner-General I undertook the consideration of the commercial and business aspects of the iron and steel industries as they were represented at the Exposition, and such observations as I may submit in the following pages will be strictly in accordance with this understanding, leaving to others the presentation of facts and opinions affecting the purely technical and scientific aspects of these industries. A few preliminary remarks of a general nature will, however, be permitted.

In strong contrast with the action of our own government in regard to the Philadelphia Exhibition, the French Government, rightly appreciating the benefits to be derived from international displays of industrial products, promptly resolved that the Exposition should be held, and assumed the expense of its creation and management: the people, thus encouraged and thus directed, labored with a patriotic pride and a concentration of effort worthy of all praise to secure its success. Every branch of the government and all classes of the people realized that the honor, the glory, and the welfare of France would be promoted by the Exposition, and there were therefore no serious impediments placed in its way and no jealousies engendered to cast reproach upon the French name. The Exposition was as completely successful as all France desired that it should be, and France is richer to-day, her people are more generally employed, and her future is brighter, than if it had not been held.

The part taken by France in supplying contributions to her own Exposition was such as would naturally result from the favorable conditions above mentioned; it was most creditable to her resources and to the skill of her industrial classes. With one exception the part taken by every other progressive industrial nation which participated in the Exposition was also in the main adequate and satisfying. The United States formed the exception; neither her natural resources nor the mechanical skill and achievements of her people were adequately represented. It will be for others to state all the reasons for this inadequate display; I desire merely to add my testimony in emphasizing the fact that all the nations which made adequate displays of their products at Paris commenced to prepare their exhibits at an early day after the holding of the Exposition was determined upon. France, Great Britain, Sweden, Russia, Austria, Italy, Belgium, and the Australian Colonies were in the van of preparation; only the United States, of all the leading industrial nations of the world, lagged behind. Our display, although with few exceptions excellent in quality, was not sufficient in extent, and not therefore fully representative of our varied resources. It would seem to be demonstrated by our incomplete exhibits at Vienna and Paris that we have not yet fully awakened to the importance of international industrial exhibitions; if the American people were more thoroughly in earnest in this matter the government would also be. If we would widen the area for the consumption of our agricultural and manufactured products, and if we would increase our commerce, we must not sit with folded hands

and wait for customers to come to us, but swiftly as opportunity offers go in search of them. May we not learn wisdom in this matter from that mother country which has taught us so much already? At all the international exhibitions that have yet been held the products of British workshops were well represented, and upon each occasion were second only to the exhibits of the country which had invited their competition.

Approaching the subject of the iron and steel exhibits at Paris, it is proper at the beginning to say that so complicated and expensive are the modern processes for converting iron ore into partially or wholly finished products that they are practically excluded from all international exhibitions; while, even if exhibited, they could not, for obvious reasons, be shown in operation. Other manufacturing processes, notably such as relate to the production of textile fabrics, were freely displayed at Paris. Of the machinery connected with the manufacture of iron and steel, and the designs and models of such machinery, there was comparatively little on exhibition to suggest that marvelous mechanical and scientific progress which is well known to characterize to-day the industrial development of all iron-making countries. More perhaps than any other great industry, that which embraces the manufacture of iron and steel was represented at Paris by its fruits rather than by its methods. But how numerous, and varied, and wonderful were these fruits! Of machinery used in other manufacturing industries, and made mainly or wholly of iron and steel, the display was in an economic sense the most imposing feature of the Exposition. Indeed, the presence of labor-saving machinery and its products was the great industrial base, and pillar, and crown of the Exposition, as it had been of other recent international exhibitions.

It may here be remarked that, on the Continent of Europe, and to a certain extent in Great Britain, the manufacture of heavy machinery, railway rolling stock, steam engines, military material, etc., is more generally conducted in connection with the manufacture of iron and steel than in this country. Locomotives, railway cars, and ordnance, for instance, are not manufactured by a single establishment in the United States which makes iron and steel, but in Europe the combination of industries indicated is frequently met. Whether the economical results are satisfactory, or not, is simply a question of administration; but the fact is to be noted that the European system of consolidating industries has scarcely an existence in the United States. The genius of our institutions, the varied

resources of our country, and its vast extent are influences which encourage individual enterprise and a separation of industries.

COUNTRIES WHICH PRODUCE THE MOST IRON AND STEEL.

The leading iron and steel producing countries of the world are as follows in the order of their prominence: (1) Great Britain, (2) United States, (3) Germany, (4) France, (5) Belgium, (6) Austria and Hungary, (7) Russia, (8) Sweden. These countries produce more than ninety-eight and a half per cent. of the world's annual increase of iron and steel. All were represented at the Paris Exposition, except Germany. All other countries unitedly produce less than one and a half per cent. of the annual increase. The iron resources of most of these countries were, however, represented at Paris. The following table of the total annual production of pig iron and castings from furnaces and of steel is compiled from the latest statistical data accessible. The tons used are English tons of 2,240 pounds.

COUNTRY.	Cast and Pig Iron.			Steel.		
	Year.	Production. Tons of 2,240 lbs.	Per cent. of Total.	Year.	Production. Tons of 2,240 lbs.	Per cent. of Total.
Great Britain	1878	6,300,000	45.63	1878	1,100,000	39.70
United States	1878	2,301,215	16.67	1878	735,000	26.53
Germany, including Grand Duchy of Luxemburg	1876	1,816,672	13.16	1876	384,159	13.87
France	1878	1,417,073	10.26	1878	281,801	10.17
Belgium	1876	562,086	4.07	1877	100,000	3.61
Austria and Hungary	1876	443,689	3.21	1876	113,152	4.08
Russia	1875	420,035	3.04	1875	12,720	.46
Sweden	1876	346,955	2.51	1876	23,592	.86
Other Countries	1877	200,000	1.45	1877	20,000	.72
Total		13,807,725	100.00		2,770,524	100.00

FRANCE.

By far the finest exhibit of iron and steel and their products ever made by France was made at her own Exposition in 1878. Her exhibit of iron and steel proper was also greatly superior in size and variety to that made at the same or at any previous international exhibition by any other country. It excited the astonishment and elicited the admiration of all who thoughtfully exam-

ined it, for few who looked upon it had before realized how largely French skill and enterprise had been enlisted in the manufacture of the more finished forms of iron and steel. In the manufacture of crude iron, castings, bar iron, iron and steel rails, and some other heavy products, the world had known at least since the Paris Exposition of 1867 that France was largely engaged, and that in their skillful and economical production she was not behind any other nation; but at the Exposition of 1878 she showed that in the manufacture of the most advanced forms of iron and steel and many of the products derived from them she had been enterprising and successful beyond all expectation. At Vienna in 1873 and at Philadelphia in 1876 France made a very poor display of her iron and steel resources and capabilities. For this the destructive war from which she had but recently emerged was doubtless the principal cause. But in 1878 she came grandly into line with other iron and steel producing nations of the first rank, her steel exhibit being especially noticeable and surprising.

Of the various exhibits made by the iron and steel makers of France, that of Schneider & Company, of Creusot, was the most conspicuous and the most complete. It was closely followed by the exhibit of the Terre Noire Company, and it in turn by the exhibit of the Saint Chamond Company. Each of these exhibits was displayed in a pavilion erected in the immediate vicinity of the main Exposition building, that of Schneider & Company being the largest special building attached to the Exposition.

In the Creusot exhibit the object which first attracted the visitor's attention, at the entrance to the pavilion, was the wooden model of the immense 80-ton steam hammer, finished at Creusot in 1877. This hammer is the largest in the world, and is said to possess more than three times the power of the celebrated 50-ton Krupp hammer at Essen. A hundred-ton forging may be turned with ease upon its anvil by means of its four powerful cranes. The large sum of $500,000 is said to have been the cost of this hammer and its accessories and of the building erected for it at Creusot. Scarcely less wonderful as a metallurgical monster was the Siemens-Martin steel ingot, cast by the same company in April, 1878, and weighing 120 metrical tons, a wooden model of which was placed on exhibition. By the side of this ingot stood another wonder—a massive armor plate, 13 feet 10 inches long, 8 feet 6 inches wide, 2 feet 7 inches thick, and weighing 65 metric tons. This plate was intended for a ship's turret. Somewhat in the same line as the objects

above noticed was a marine engine of 2,640 horse-power, with three upright cylinders, one of 5.49 feet and each of the others of 6.10 feet in diameter. Eight boilers were provided to supply the steam. The weight of the engine was 290 metric tons, and that of engine and boilers was 480 tons. There was also exhibited an exceptionally large cast steel shaft for a screw propeller, for a French naval vessel. This forging was 60 feet 4 inches long and 17 inches in diameter, and weighed 44,651 pounds, or about 20 tons. There were many other exhibits in the Creusot pavilion which indicated great facility in the manufacture of heavy machinery and warlike material for use on land or sea. There were also locomotives; iron and steel rails, plates, sheets, and wire; steel tires, iron bars, angles, and beams; and many other iron and steel products—all of good quality. A model of a modified Danks puddling machine was also exhibited, with various products. This modification overcomes difficulties in machine puddling heretofore experienced in England and the United States, and it practically dephosphorizes the iron worked in it. It represents a step forward. Two of these machines are regularly at work at Creusot, giving good results, each of them producing 20 tons in 24 hours. A circular steel plate, about 90 inches in diameter, attracted attention. Models and drawings of bridges, engines, mines, workingmen's houses, etc., and of the town of Creusot itself, were liberally distributed throughout the building; as were also samples of the ores, coal, and refractory materials in use at Creusot. The whole display was most imposing, and was the finest single exhibit of iron and steel ever made at an international exhibition.

The works of Schneider & Company are mainly situated at Creusot, in the department of the Saône and Loire, where a Bessemer plant of 6 eight-ton converters, a Siemens-Martin plant, (both commenced in 1869,) blast furnaces, plate mills, gun factory, mines, etc., are located; but their locomotive, boiler, bridge-building, shipbuilding, and marine works are situated at the neighboring town of Chalons, on the river Saône. There are also coal and ore mines, brick works, etc., elsewhere. The ground occupied by the furnaces, rolling mills, steel works, constructing shops, and other buildings used by the company at Creusot and Chalons covers 60 acres; and the total area occupied by the works, dwellings of workmen, and railroads at the works is 1,058 acres. The number of miles of railroad operated is 188, upon which 27 locomotives and 1,518 cars are used. In all departments of the company's works there are

in use 281 engines other than locomotives, 58 steam hammers, and 1,050 steam machine tools. In the last fiscal year there were produced 549,000 metric tons of coal, 155,000 tons of pig iron, 126,000 tons of wrought iron and steel; and 25,000 tons of iron and steel products in the constructing shops. In the same year 400,000 tons of iron ore were consumed in 13 blast furnaces. These furnaces are from 72 to 82 feet high, and are supplied with Whitwell and Cowper fire brick stoves and with immense blowing engines. All the Bessemer iron is run direct from the blast furnaces to the converters. In recent years the average annual production of steel rails has been 50,000 tons; of iron rails, 20,000 tons; and of locomotives, 100. The total sales of the company amounted to $15,000,000 in the fiscal year 1874–5, and to $11,600,000 in the fiscal year 1877–8. During the past ten years the aggregate sales have amounted to $105,000,000. The company employs 15,000 persons. Its nominal capital is 27,000,000 francs, or $5,211,000. The works at Creusot were founded in 1781, but they did not begin to assume any of their present importance until 1836, when they passed into the hands of Messrs. Schneider Brothers & Company.

The Terre Noire exhibit, although not so large as that of Creusot, was more consecutive and instructive, in showing grades of steel and the results of using metalloids. It comprised an interesting and very full collection of ores, coal, pig iron, ferro-manganese, and spiegeleisen; bent and fractured bars; polished bars and rails; hammered, rolled, and fractured samples of various kinds of steel; cast iron pipes of various diameters; beams, some of which were 68 feet long; galvanized iron; chains; locomotive axles; steel ingots; solid steel castings, etc. The bent and fractured specimens of iron and steel showed the quality of these metals to be excellent. There was also exhibited a model in wood of the immense blowing engine of the Bessemer plant of the company at Bességes, and a fine drawing of the large blowing engine of the blast furnaces at Tamaris; also models, drawings, and photographs of much other machinery, including photographs of the large plate train, just completed, which will roll a plate 36.08 feet long, 8.2 feet wide, and 3.9 inches thick. But the feature of the Terre Noire exhibit which attracted most attention was the display of solid steel castings, made by a process peculiar to Terre Noire, but a modification of the ordinary Siemens-Martin process. Cannon and projectiles are the principal articles made by this process, which produces a true steel free from blow-holes. The process has been briefly described to consist in the use

of a silicide of manganese and iron, the silicon preventing blow-holes by decomposing the oxide of carbon which is in solution and tends to escape during solidification, while the manganese reduces the remaining silica and the oxide of iron and prevents a further production of gases by the reaction of the oxide on the carbon. About 200 tons of castings are produced monthly by this process.

The works of the Terre Noire Company are greatly scattered, the principal branch, however, being at Terre Noire, in the department of the Saône and Loire. The extensive operations of the present company had their origin in the purchase of the iron mine of La Voulte, in 1810. In 1862 the erection of a Bessemer plant was commenced at Terre Noire, and in 1868 a Siemens-Martin plant was established at the same place. A Bessemer and a Siemens-Martin plant were established at Bességes in 1868. The company owns 19 blast furnaces and all the usual appliances of an advanced and comprehensive iron and steel establishment. It has 15 Siemens-Martin furnaces, 8 Bessemer converters, 84 puddling and 55 reheating furnaces, 12 steam hammers, and 28 roll trains for iron and steel. Its buildings cover 28 acres; it operates with 10 locomotives 76 miles of railroad connected with its various works; and it employs 7,881 persons. Two of the Siemens-Martin furnaces have a nominal capacity of 15 tons each, and have made heats of 22 tons each.

In the Bessemer practice of the Terre Noire Company spiegeleisen is melted in a Ponsard furnace, which requires 25 pounds of coal to melt 100 pounds of metal. One furnace serves four converters, but the latter, which are on the ground floor, are small and convert only four tons at a heat. At Terre Noire the metal is charged direct from the blast furnace into the Bessemer converter. At some of the blast furnaces of the company Siemens-Cowper stoves are used. The company is noted for its production in commercial quantities of high grade ferro-manganese in the blast furnace. The highest it has made contains 85 per cent. of manganese, 6.7 per cent. of carbon, and 8 per cent. of iron. Ferro-manganese of from 71 to 75 per cent. of manganese is made from ores of 36 to 40 per cent. of manganese, and with about 2.75 tons of coke to the ton of product, the blast being about 715° C. An average daily production of 11 to 12 tons is obtained in a furnace which would produce 42 tons of Bessemer pig iron in the same time. Ferro-silicium is also manufactured at Terre Noire in the blast furnace, the composition of two samples being as follows: (1) iron, 68.50; manganese, 20; carbon, 1.50; silicium, 10. (2) Iron, 76.77; manganese, 14;

carbon, 1.60; silicium, 7.50. The Siemens-Martin plant at Terre Noire is very complete and elaborate. The cost at these works of a metric ton of Siemens-Martin steel, made by the "pig and scrap" process, is given as follows: materials used in the charge, $21.80; coal, $1.94; labor, $4.10; total, $27.84. In 1877 the Terre Noire Company produced 106,000 metric tons of coal, 200,000 tons of iron ore, 158,000 tons of pig iron and spiegeleisen, and 147,600 tons of cast and wrought iron and steel.

The pavilion occupied by the enterprising company of iron and steel manufacturers at Saint Chamond, also in the department of the Saône and Loire, was well filled with specimens of cannon and projectiles; railroad material and marine appliances; iron and steel beams, bars, plates, and sheets; steel tires and springs; pig iron, spiegeleisen, iron ores, etc. The company makes a specialty of railroad and marine work. Several locomotives and cars and a large collection of polished and fractured iron and steel rails were exhibited; also car wheels of wrought iron with steel tires. Of the marine articles on exhibition several armor plates of great thickness were most conspicuous. Some of these were rolled much thicker at one edge than at the other, the thinner part to go under the water. The fragment of an iron armor plate thus rolled was shown, one edge of which was 14 inches thick and the other 9 inches; several indentations showed that, notwithstanding its thickness, it had been almost perforated by projectiles hurled against it. A model of the rolls by which these plates were produced was exhibited. The display of steel cannon and cast steel cannon balls was large, the tube of one cannon weighing almost 7 metric tons. A cast steel ingot, weighing 40 metric tons; a steel crank axle, weighing 3½ tons; a ship's keel of wrought iron, 49 feet long, and weighing 5,170 pounds; and several large cast steel plates, for various purposes, were especially noticeable. Cast steel beams; steel discs for circular saws; thin sheets of crucible steel; bent, twisted, and fractured bars of iron and steel, and many other specimens completed a very interesting collection of iron and steel products. Of the models shown there was one of a twenty-ton Pernot furnace in use at the works. The steel made at Saint Chamond is made in Siemens-Martin-Pernot furnaces. Iron is also puddled in Pernot furnaces. The works produce beams, springs, tires, cannon, rails, armor and other plates, and merchant iron and steel. Steel beams are a specialty, and are made up to two feet in width by a peculiar universal train.

The company which operates the extensive works at Saint Chamond has a capital of $2,600,000; employs from 5,000 to 6,000 workmen; and manufactures from 40,000 to 45,000 tons of iron and steel annually. Its works proper are in five divisions, and in addition it has seven blast furnaces—four cold blast charcoal in Corsica and three hot blast coke near Saint Chamond.

In the main building of the Exposition and in the annexes there were exhibited the products of many other iron and steel establishments of France, a majority of all these establishments in the country being represented. Specimens of pig iron and iron ores from all parts of France and adjacent sources of supply were shown. One of the largest armor plates at the Exposition was exhibited by Marrel Brothers; it was 13.94 feet long, 5.24 feet wide, 2.34 feet thick, and weighed 38 metric tons. It was made of puddled iron. The Marseilles Company exhibited specimens of spiegeleisen and ferromanganese from its Saint Louis blast furnaces, and also exhibited ores from Italy, Spain, and Algeria. The Denain and Anzin Company presented a very imposing column of iron and steel rails and other iron and steel products, including iron made in a revolving puddling furnace of the Crampton pattern. The Champagne Company exhibited a large collection of iron ores, and of pig iron made with both charcoal and coke. Jacob Holtzer & Company exhibited chrome pig iron and steel, the latter showing a very fine fracture. This firm also exhibited a very large and complete assortment of steel bars of all sizes, as well as steel castings, tools, cannon, and raw materials. The Company de l'Horme showed samples of wrought iron tempered in sulphuric acid to increase its tensile strength. The Coal Company of Anzin, the largest mining company in France, exhibited a fine model of its mines, at which are employed about 15,000 persons. This company owns about 70,000 acres of land, and produces about 2,000,000 tons of coal annually.

The display made by France of steam engines and locomotives was the largest in the Exposition, and showed to great advantage. Many of the engines were in motion, and in ease of movement, smoothness of finish, and adaptation to the uses to which they were applied they compared favorably with the best engines in use in the United States. I was especially pleased to see two Corliss engines of French manufacture in operation, each of about 50 horse-power. The largest engine in the Exposition building was a French engine of 700 horse-power. The display of pumping machinery was large, as was also that of machinery for the manufacture of beet

sugar, which machinery we have not yet had occasion to make in our own country. In mining machinery the French department was rich, and it was apparent that in the working of coal mines especially the French had made great progress and have probably no superiors. Of agricultural machinery the French display was exceedingly creditable. Although Great Britain and the United States each surpass France in this field of invention, it must be conceded that she is rapidly adopting their best conceptions, and a field trial of competing agricultural machinery during the summer, which I witnessed, fully attested this fact. France, indeed, manifests wonderful progress in the quickness with which she perceives and the readiness with which she accepts foreign mechanical ideas. Long ago Nasmyth, the English inventor of the steam hammer, found that Frenchmen could perceive its great advantages and possibilities when his own countrymen could not. Neilson's hot-blast, invented in Scotland in 1828, was used in France in 1832; the manufacture of Bessemer steel, invented in England in 1857, was introduced into France in 1859 at Sireuil. The Whitwell stoves are in more general use in France than in England. The most recent exhibition of this progressive mechanical spirit is, perhaps, shown in the introduction upon at least two French railroads of the Westinghouse air brake, an American invention. In the substitution of steel for iron, now rapidly taking place in many countries, France is not behind any of her cotemporaries.

The French display of machine tools, wood-working machinery, textile machinery, gas and water pipe, general castings, cooking-ranges, saws, and edge tools, and fine cutlery was in the main praiseworthy, and in some respects unsurpassed in quality, as it was unequaled in extent and variety. English exhibitors of competing articles frankly admitted the excellence of these exhibits, and with regard to some of them they also admitted that France would hereafter fully supply her own markets, and in part supply the markets of her Continental neighbors.

A pamphlet lies before me which contains a list of several hundred blast furnaces and iron and steel rolling mills in France. It is noticeable that more than one-half of the rolling mills are connected with blast furnaces; and it is also worthy of remark that the iron and steel industries of France are widely distributed, showing an equally wide distribution of the raw materials of manufacture and great facility in procuring those of neighboring countries. Her own large supply of native ores is supplemented by the abundant supply

of foreign ores of extraordinary richness which are found near at hand in Elba, Spain, and Algeria; while Belgium and Germany may be drawn upon for ores of comparatively inferior quality. The substitution of Bessemer steel for iron has largely decreased the mining of native ores in France, and increased the use of Spanish and Mediterranean ores. In 1877 the production of the former was about 2,000,000 tons, and the importation of the latter was 975,631 tons. In 1878 the importation was 932,284 tons. France exported 79,113 tons of ore in 1877, and 79,536 tons in 1878.

The annual production of coal in France is about 17,000,000 tons, the annual consumption about 23,000,000 tons, and the annual exportation to neighboring countries about 800,000 tons, leaving about 7,000,000 tons to be imported. This deficiency is supplied partly from Belgium, and partly from England and Westphalia. In 1876 Belgium furnished 50 per cent. of the whole importation, England 36 per cent., and Westphalia 14 per cent. About 700,000 tons of artificial fuel, or briquets, are annually manufactured in France from the refuse of coal mines. The production of coal in France has doubled since 1860. The coal measures are principally found in the departments of Pas-de-Calais, Nord, Loire, and Saône-et-Loire.

The production of pig or cast iron in France amounted to 112,500 metric tons in 1819, to 266,361 tons in 1830, to 347,773 tons in 1840, to 415,653 tons in 1850, to 898,353 tons in 1860, and to 1,260,348 tons in 1866. During the years 1874 to 1877 the production was annually about 1,400,000 tons. The exact figures for 1878 are not authoritatively published, but the approximate production for the year has been placed at 1,417,073 tons, showing a slight increase. In 1861 there were 472 blast furnaces in France, of which 282 used charcoal, 113 coke, and 77 mixed charcoal and coke. In 1872 the total number of furnaces had decreased to 270, although the production of the year was much greater than that of 1861, the substitution of coke for charcoal and the use of larger and better furnaces accounting for the decrease in the whole number. Of the 270 furnaces in 1872, only 89 used charcoal, and 46 a mixed fuel; the remaining 135 used coke. The annual production of charcoal pig iron is now less than 100,000 tons. It is still customary in some parts of France to make rough castings direct from the blast furnace, (classed as pig in the above statistics,) and in the Pyrenees iron is still made by primitive processes.

The manufacture of iron rails in France began about 1840, and

in 1850 the production was only 23,087 metric tons. In 1860 it was 121,348 tons, and in 1869 it was 216,628 tons. In 1872 it had fallen to 129,151 tons; in 1875 to 118,959 tons; in 1876 to 77,420 tons; in 1877 to 73,103 tons; and in 1878 to 53,884 tons.

The production of merchant iron (not including plates and sheets) amounted to 149,652 metric tons in 1850, and to 710,935 tons in 1872. Since 1872 this production, like that of iron rails, has decreased, the make in 1877 being 589,559 tons, and in 1878 being 608,764 tons. The production of plates and sheets amounted to 100,915 metric tons in 1865, and to 129,843 tons in 1872. The make in 1877 was 107,451 tons, and in 1878 it was 105,688 tons.

The decrease in the production of iron rails and merchant iron and the stationary production of iron plates and sheets are results almost wholly due to the rapid increase in the manufacture of steel. In 1831 there were only 4,915 metric tons of steel of all kinds made in all France; in 1840 the production was only 8,263 tons; in 1850 it had reached to only 10,982 tons; but in 1860 it jumped to 29,849 tons; in 1872 it was 141,705 tons; and in 1878 it was 281,801 tons, of which 253,536 tons were made by the Bessemer and Siemens-Martin processes, and the remainder by various older processes. The manufacture of crucible cast steel in France does not appear to have ever much exceeded 8,000 metric tons annually, the production in 1870 being 8,135 tons, and in 1872 being 8,080 tons. Of the reported production of 253,536 tons of Bessemer and Siemens-Martin steel in 1878, the quantity rolled into rails is placed at 211,519 tons. In 1876 there were in France 26 Bessemer converters and 25 Siemens-Martin furnaces.

The imports of pig iron into France amounted to 212,897 metric tons in 1877, and to 166,487 tons in 1878; of iron in other forms to 62,736 tons in 1877, and to 69,965 tons in 1878; and of steel to 5,009 tons in 1877, and to 6,173 tons in 1878. Against this importation France exported 169,205 tons of her iron and steel products in 1877, and 168,704 tons in 1878. France had 13,220 miles of railroad in June, 1878.

In view of the present magnificent development of the iron and steel industries of France, the conclusion is fully warranted that these industries have before them a most promising future.

GREAT BRITAIN.

The exhibit at Paris by Great Britain of iron and steel and their products has been freely characterized by representative Englishmen,

and by representative English journals, as incomplete and unsatisfactory—not worthy of the vast mineral resources and still vaster metallurgical progress of their country. Taken in detail, the display of these articles may have justified this criticism; but as a whole it was extensive, varied, and exceedingly suggestive of mechanical excellence. No other nation except France made so imposing a display of steel, of cutlery, of armor plates, of stationary and other engines, of steam pumps, and of machine tools; while its display of agricultural implements and machinery, of textile machinery, and of general hardware was the finest in the Exposition. Its entire display of machinery and tools was more than creditable—it was magnificent; and yet it must be confessed that, omitting this feature, and omitting also the splendid show of hardware and cutlery, the exhibit of iron and steel and their products by the leading nation of the world engaged in their manufacture was not such as she could have made nor such as was due to her reputation. Especially was there noticeable the absence of a large assortment of the products of the Bessemer and open-hearth processes, in the invention and perfection of which processes Great Britain is entitled to the highest honors. Such products as were exhibited were chiefly Bessemer rails and Siemens-Martin plates, and the absence of others would seem to warrant the conclusion that on the Continent and in the United States the tendency to adapt Bessemer and open-hearth steel to the manufacture of articles for which other steel and iron have heretofore been required is stronger than in Great Britain. This view would, however, be erroneous. Great Britain failed to make a complete display of the capabilities of Bessemer and open-hearth steel, but she has not, therefore, confessed that she has failed to observe and to utilize them. On the contrary, there is abundant evidence, to be noted farther on in this report, that she is abreast of other nations in adapting Bessemer and open-hearth steel to miscellaneous uses.

Of the display of Bessemer steel in the British section the prominent firm of Bolckow, Vaughan & Co., of Middlesbrough, contributed finished products in various forms, but principally rails from their steel works at Eston, which were established in 1877, have four eight-ton converters, and can produce 2,000 tons of rails weekly. They also contributed complete samples of the raw materials used at their works, the ore coming from the West Coast of England and from Bilbao in Spain. The well-known firm of Brown, Bayley & Dixon, of Sheffield, made a fine display of Bes-

semer rails, tires, axles, plates, bars, etc. They exhibited a rail 130 feet long, rolled direct from the ingot, and bent into four lengths of 32 feet each, the whole measuring 4½ feet across. Among the tires exhibited by this firm were two of 9 feet in diameter, one polished and the other unpolished. Their locomotive springs were very fine, as were their large and small chains. The celebrated steel-making firms of John Brown & Co., and Charles Cammell & Co., of Sheffield, also exhibited samples of their Bessemer rails, axles, etc. Steel armor plates formed an impressive feature of their exhibits. A Bessemer steel boiler plate, of superb quality, which had been subjected to a test of the utmost severity, was exhibited by the West Cumberland Iron and Steel Company. Of Siemens steel, made by the "ore" process, the only noticeable display was made by the Landore Company, of which Dr. Siemens himself is the head. The exhibit of this company, in an annex to the main building, embraced specimens of rolled and forged steel in various minor forms; also heavy ship plates of the same material; also rails, angles, beams, tires, and axles. The exhibit was scarcely such in location, style, and variety of samples as might have been expected from this company.

One of the most interesting of the British steel exhibits was that which embraced various samples of the "Whitworth metal," to which much importance has been attached in Great Britain in connection with the manufacture of ordnance and other articles by the Siemens and Siemens-Martin processes. The exhibit was large, and of a character to favorably impress the visitor. The metal is made of more than ordinary solidity and tenacity by being cast under hydraulic pressure. Cannon and shells of this metal are said to withstand the severest tests, a claim that received confirmation from some of the samples submitted. A propeller shaft was exhibited, forged hollow, which it was claimed was much stronger than a solid wrought iron shaft of the same size and weighing one-half more. This shaft, forged from a hoop of compressed steel, was 33 feet 7 inches long, the outside diameter 17½ inches, and the diameter of the bore 11⅜ inches. A hydraulic cylinder of this metal was shown which was represented to stand a pressure of four tons to the square inch. For machine tools, in which strength combined with lightness is desirable, the compressed steel is claimed to have no equal. Sir Joseph Whitworth's aim has been to produce a steel that would be free from blow-holes, and this result he has accomplished by mechanical means. It has already been stated in this

report that a similar result has been claimed by the Terre Noire Company, in France, through chemical combinations.

Hadfield's Steel Foundry Company, of Sheffield, exhibited crucible steel castings in various forms, principally, however, as railroad appliances, including very light wheels for street railroads. The wearing qualities of these wheels are doubtless excellent, but they are hardly superior in this respect to American chilled cast iron wheels, while they are much more expensive. Their extreme lightness, however, is a recommendation, although it may be doubted whether they are much, if any, lighter than the best cast iron wheels on American street railroads. Steel wheels of various sizes, from colliery sheaves to car wheels, made from Attwood's steel, at the Stanner's Close's Steel Works at Wolsingham, were also exhibited, as were other steel castings and steel forgings from the same works.

The exhibit made by the cast steel makers of Sheffield was not large, but it was interesting and valuable. Tool steel was shown in great variety by Guy & Company; Jowitt & Sons showed circular saws, with perforated teeth; one of the saws was 7 feet and 3 inches in diameter; Siebohm & Dieckstahl exhibited many fine steel fractures, showing their steel to be of exceptional excellence; other firms showed cast steel in various forms and tools made from it. Andrew & Company, of the Toledo Works, showed a piece of cast steel wire rod, No. 2 wire gauge, 1250 feet long. Thomas Turton & Sons made a fine display of cast steel springs. But the most extensive of the Sheffield cast steel exhibits was that of William Jessop & Sons, who exhibited a full assortment of their products, a leading feature of which was a steel disc or saw plate, 10 feet 8 inches in diameter, $\frac{9}{16}$ of an inch thick, and weighing 2,688 pounds. This firm also exhibited a block of best cast steel, 20 inches square and weighing 1 ton and 10 cwts.; also other ingots of large size, broken and showing fine fractures; also specimens of crucible steel boiler plate, bent, twisted, and punched cold. A few cast steel manufacturers at Newcastle-on-Tyne and elsewhere also exhibited their products.

Sheffield made a good display of cutlery, saws, and edge tools, and this was supplemented by like contributions from other British manufacturing centres; but the whole British exhibit of these articles was inferior in extent to that of France, and in some respects was fully equaled by it in quality. The French saws at the Exposition were especially noticeable and excellent.

Of iron products proper and the raw materials of their manufac-

ture the best display in the British section was made by the Cleveland and North of England district. The ironmasters of this district showed commendable enterprise in the extent, variety, and neatness of their display. They exhibited the exact quantity of coke, ore, and limestone used in the production of one ton of Cleveland pig iron, namely, a pillar of native iron ore, 10 feet high and weighing $3\frac{6}{20}$ tons, 24 cwts. of Durham coke, and 12 cwts. of Weardale limestone. Various samples of pig iron, castings, wrought iron tubes, plates, sheets, rails, girders, etc., were also shown. The castings exhibited by the proprietors of the Acklam Works, at Middlesbrough, including garden chairs, umbrella stands, and similar light wares, were cast directly from the blast furnace, the better to show the quality of the Cleveland metal for foundry purposes. Mr. I. Lowthian Bell, M. P., exhibited samples of Cleveland iron from which the large percentage of phosphorus originally contained in it (1.2 to 1.75) had been almost entirely removed by his oxide of iron process. He also exhibited samples of steel made from this iron. Specimens were also shown by Hopkins, Gilkes & Co., of Middlesbrough, of iron made in the Danks puddling furnace, from Cleveland pig iron. They fully established the claim for excellence that has been made for this iron, and it was not surprising to learn that it is competing with the best Staffordshire brands. It possesses a tough fibre and great tensile strength. Siemens-Martin steel made from this iron was also exhibited. The Danks furnace has been proved to be a powerful agency in the elimination of phosphorus from Cleveland pig iron, but, although successfully competing in quality and price in the manufacture of the very best bar iron, the proprietors can not, by its instrumentality, make iron rails of sufficient hardness to compete with Bessemer rails in wearing qualities.

The Cleveland and North of England district is the most productive iron district in the world. It embraces less than three English counties—Northumberland, Durham, and the North Riding of Yorkshire, and yet its annual production of pig iron during the years 1871 to 1878, both inclusive, averaged over 2,000,000 English tons. In each of these years it produced more pig iron than any other country, the United States alone excepted, and in the years 1875, 1876, and 1877 it produced more than the United States, the exact figures for 1877 being as follows: Cleveland, 2,138,378 tons; United States, 2,066,594 tons. In 1878 the production of Cleveland declined to 2,023,177 tons, which was less than that of the

United States in the same year. There are 165 blast furnaces in this district, some of them being the largest in the world. Of these, 92 were in blast and 73 were out of blast in December, 1878. In 1840 the number of blast furnaces was less than a dozen, and they were all small. The district produces about one-third of the total pig iron product of Great Britain. It also produces over 31,000,000 tons of coal annually, or about 23 per cent. of the immense coal product of the kingdom. Until a year or two ago it was also very prominent in the manufacture of finished iron. Of 7,159 puddling furnaces in all Great Britain, 1,894 are to be found in this district. The extreme cheapness with which Cleveland pig iron can be made brings it into successful competition with the pig iron of Scotland and other districts of Great Britain, and with that of Belgium, Germany, and other Continental countries. The fact is to be noted, however, that, notwithstanding this cheapness and the rapid growth of the Cleveland iron district in the last ten years, the exports of pig iron from all Great Britain since 1873 have annually been less than in 1871, showing that Cleveland pig iron is merely taking the place in foreign markets of other British pig iron, particularly that of Scotland.

The district of South Staffordshire is the great centre of the finished iron trade of England. It contains 125 separate and distinct iron works, or, as we say in our country, rolling mills, having over 2,000 puddling furnaces out of a total of 7,159 in the whole of Great Britain. It also contains 148 blast furnaces out of a total of 977 in the kingdom. Of the whole number in the district, only 38 were in blast in December, 1878. But of the large iron interests packed in this small territory very little display was made at Paris. Several firms exhibited specimens of sheet iron, some of which were bent into various shapes to show their excellent quality.

Earl Granville, of North Staffordshire, and the Lilleshall Company, of Shropshire, showed samples of their iron ore, coal, and pig iron; the Snedshill Iron Company, of Shropshire, made a fine display of boiler plates, rods, bars, etc.; the Shelton Bar Iron Company, of North Staffordshire, showed fine samples of its rails, angles, tees, girders, plates, etc.; the North Lonsdale Iron and Steel Company, and the firm of Harrison, Ainslie & Company, both of Lancashire, showed samples of their pig iron and raw materials. The Leeds Forge Company, of Leeds, Yorkshire, exhibited in a small case samples of excellent boiler plate, folded sixteen times without cracking; also shafts and locomotive axles of superior

quality. This company also exhibited Fox's patent corrugated flue for steam boilers, the invention of Mr. Sampson Fox, the managing director of the company. This flue is made from best Yorkshire cold blast pig iron, and the following advantages are claimed for it: "Increased strength against collapse; much thinner plate than usual may be used, and higher pressure adopted with increased safety; increased heating surface; a more effective heating surface, due to flame impinging on corrugated surfaces; more elasticity longitudinally compared with a plain flue; and increased circulating action of the water, due to steam being formed in the annular grooves or corrugations." W. B. Wright & Co., of Bristol, exhibited specimens of their galvanized sheet iron, including a sheet 16 feet long, with eight 3-inch corrugations, and of 24 Birmingham wire gauge, claimed to be the largest sheet of the kind ever rolled. Other specimens of galvanized iron sheets were exhibited in the British section; also tin and terne plates, galvanized and other wire, and a long list of minor iron and steel products.

The iron and steel industries of Scotland and Wales were very meagrely represented. In Scotland there are 22 rolling mills, 345 puddling furnaces, and 155 blast furnaces. In all Wales and Monmouthshire there are over 20 rolling mills, over 800 puddling furnaces, and 174 blast furnaces. The great iron shipbuilding firms on the Clyde, the Tyne, and the Thames made no sign. Of iron bridges, or the parts composing them, there was no display worthy of special mention. Of the excellent coal and coke of the United Kingdom the display was ample.

But what Great Britain lacked in iron and steel exhibits she made up in all kinds of machinery. Her display of agricultural machinery was very large, the best she ever made, but its merits were stoutly contested by French and American exhibitors. Of mowers, reapers, threshers, cultivators, plows, and the long line of agricultural machines and implements now regarded as essential to progressive agriculture, the British section contained a large and excellent assortment. A prominent feature of the British agricultural machinery exhibit was the steam plow, which has not yet been brought into use in either France or America, except experimentally, although largely employed in England. The introduction of this great labor-saving machine upon our Western prairies may be presumed to be among the possibilities of the near future, as may also the introduction upon American farms of another feature of European agriculture, the beet sugar industry. In the

British section there was a display of stationary, portable, locomotive, fire, and marine engines that was almost bewildering in its extent and variety. Galloway & Son, of Manchester, exhibited a 300 horse-power engine which attracted much attention. It had two cylinders, one high and the other low pressure. The workmanship was excellent. Of steam pumps, hydraulic cranes and other hydraulic machinery, portable forges, steam hammers, woodworking machinery, and machine tools generally, the display was also large. Two steam cranes, exhibited by Messrs. Appleby Brothers, deserve special mention. The exhibit of textile machinery was magnificent and unequaled.

It has already been remarked that in the nature of things it is impossible to exhibit at an international exhibition many of the processes of iron and steel manufacture. In the British section there was, therefore, but little to suggest the methods by which the greatest iron and steel producing country in the world has attained its pre-eminence. A model and drawings of the Whitwell stoves were exhibited by the Messrs. Whitwell. Messrs. Brown, Bayley & Dixon exhibited a design of Cooper's patent appliance for utilizing the heat from Bessemer converters, by carrying the flame through a stack or chimney into a stove containing a series of pipes, through which the blast for melting pig iron is forced. Charles Wood, of Middlesbrough, exhibited models of his machine for the utilization of blast furnace slag. Francis H. Lloyd, of Wednesbury, showed samples of his patent open spray tuyeres for blast furnaces. Professor Barff exhibited specimens of wrought iron made impervious to rust by his coating of black oxide. In exhibits of new or curious uses for iron and steel the patent iron railway sleeper of Charles Wood, and the patent elastic embossed railway sleeper of P. & W. MacLellan, of Glasgow, may be mentioned. The superiority of wire over hempen rope, for ship's cables and ship's rigging, was shown in the exhibit of a wire rope by the side of a hempen one of double the size, but of less strength. Railway car wheels with wooden and others with paper centres were shown; the latter are not much in use in Great Britain, or in any part of Europe, but the former are extensively used on the London, Brighton, and South Coast Railroad. Another noticeable exhibit was that of iron water pipes galvanized upon the inside.

The British display of tin and terne plates and their products was, as might have been expected, large and creditable. As the manufacture of these plates is strictly a branch of the iron industry,

and a very extensive branch of the British iron industry, the fact may here be noted that it has scarcely an existence in the United States, the second in rank among iron-producing countries.

The adaptation of steel to shipbuilding was not shown in the British section by the presentation of comparative or other tests made by the British Admiralty or the British Lloyd's, although experiments on a large scale, favorable to steel, had been made by both these agencies prior to the opening of the Exposition. These experiments related to the plating of the hulls of vessels and the general substitution in their frame-work and interior construction of steel where iron is now used. As these and earlier experiments have already resulted in the building of two steel vessels for the British Government and in contracts for the building of other vessels, it is to be regretted that no record was made at Paris of the reasons that have prompted action which may lead to a revolution in the construction of both naval and merchant vessels. Nor were the bridge-building qualities of steel fully illustrated at Paris by Great Britain, although her engineers have made numerous experiments in its use for this purpose. A monograph, prepared by W. Parker, Esq., Chief Engineer Surveyor of Lloyd's Register, showing the use which has been made of steel for marine boilers, was circulated at the Exposition.

Great Britain is making great progress in the utilization of steel for all purposes to which it is adapted, the preference being for Bessemer and Siemens-Martin steel because of their cheapness. Steel boilers for stationary and locomotive engines are largely manufactured. Steel car wheels have already been mentioned. The Sheffield cutlers have commenced to use Bessemer steel in the manufacture of scissors and other cutlery. In some instances steel rail ends are used for this purpose, and in others steel of a desired quality is specially manufactured. In all railway appliances steel made by the Bessemer and the Siemens-Martin processes is rapidly displacing iron in Great Britain, as it is on the Continent. Iron, however, has found new friends in those inventors who have suggested its use in the construction of the so-called permanent way of railroads, and various systems of this new permanent way are now in daily use on the Continent. In Great Britain one or two of them have been used experimentally, and a commencement has been made in shipping iron for the construction of the permanent way of an Indian railroad.

The story of Great Britain's wonderful achievements in the

manufacture of iron and steel is best told in the statistics of their production; and, in this connection, the statistics of her coal production should not be overlooked, for it is to the existence of her immense coal deposits that her prominence in the manufacture of iron and steel is mainly due. In 1735, one hundred and forty-four years ago, the total make of pig iron in Great Britain was only 17,000 English tons. In 1854, the epoch of the Crimean war, a quarter of a century ago, it had steadily increased to 3,069,838 tons, and in 1871, seventeen years after 1854, this product was more than doubled, the production in that year being 6,627,179 tons. In 1872 there was an increase to 6,741,929 tons, the highest product yet attained. In 1877 the production was 6,608,664 tons, which was somewhat less than that of 1871. To fully realize the magnitude of these figures, comparison of them should be made with the figures representing the world's total production of pig iron in 1877. This total production was a fraction less than 14,000,000 tons; the production of pig iron by Great Britain in that year was, therefore, almost one-half of that total.

But Great Britain's progress in the manufacture of steel has been much more rapid than the development of her pig iron industry. At the period of the Crimean war her annual production of all kinds of steel was only about 50,000 tons, but immediately after the close of that war the Bessemer process was invented, and in 1878 no less than 850,000 tons of steel were made by it alone in Great Britain. In 1856 Dr. C. W. Siemens and his brother Frederick invented the Siemens regenerative gas furnace, and in 1864 it was successfully applied to the production of steel by the Martin process. In 1878 there were produced in Great Britain by the Siemens-Martin process and its near relative, the Siemens process, 174,000 tons of steel. The total production of steel in Great Britain in 1878 is supposed to have been 1,100,000 tons, which was nearly 40 per cent. of the world's production of about 2,700,000 tons in that year.

In producing her enormous annual yield of pig iron Great Britain has mainly relied upon her own supplies of iron ore. In 1877 she mined 16,692,802 tons of ore, and imported 1,142,308 tons, principally from Spain and Algeria, for use in her Bessemer steel works. In the same year she extracted 415,000 tons of "burnt ore" from imported cupreous pyrites, principally obtained in Spain. She thus smelted in 1877 a total of 18,250,110 tons of iron ore, from which were obtained 6,608,664 tons of pig iron. Only two districts in Great Britain—Northwest Lancashire and Cumberland—can supply

large quantities of ores suitable for Bessemer steel. The importation of foreign ores for Bessemer purposes is absolutely necessary.

The production of coal in Great Britain, keeping pace with that of pig iron, has more than doubled since the period of the Crimean war. In 1854 it was 64,661,401 tons, and in 1875, twenty-one years afterwards, it was 131,867,105 tons. This product was increased in the following year to 134,125,166 tons, and in 1877 it was further increased to 134,610,763 tons. The world's production of coal in 1877 has been placed at about 285,000,000 tons; so that Great Britain produces almost one-half of this product. It is stated that the largest coal field in England, with the greatest quantity of unworked coal, is the Midland, which extends from the town of Nottingham to Leeds, and is nearly 70 miles in length.

In the building of iron steam and sailing vessels Great Britain undoubtedly leads all other countries combined.

The immense quantities of iron and steel and their manufactured products which are annually exported from Great Britain to other countries will be seen in the following summary. In 1872 the maximum of yearly exports of iron and steel and their manufactures was attained, when a total of 3,382,762 tons was exported. From 1872 to 1876 the exportation of these products gradually declined in quantity to 2,224,470 tons; but in 1877 a slight increase to 2,344,651 tons took place, which was, however, not maintained in 1878, when 2,299,223 tons were exported. The value of British iron and steel exports has steadily declined from £37,731,239 in 1873 to £18,393,974 in 1878.

The exportation of coal and coke from Great Britain to other countries gradually increased in late years until 1876, when a maximum exportation of 16,299,077 tons was attained. In 1877 the quantity sent abroad fell to 15,358,828 tons. In 1860 the exports amounted to 7,412,000 tons. This quantity was more than doubled in 1876. About one-third of the total British production of coal is used in the home iron and steel industries.

The importation of iron and steel into Great Britain is annually increasing. The value of the importations in 1877 reached £1,943,-622. The imports of coal into Great Britain are so small as not to justify the quotation of exact figures. There were 17,109 miles of railroad in Great Britain at the beginning of 1878.

GERMANY.

Statistics establish the fact that Germany is entitled to a place in

the front rank of iron and steel producing countries, but none of her industries were represented at the Paris Exposition, and nothing could therefore be learned within its gates of the characteristics and present condition of her iron and steel manufactures. It would not be proper, however, if any mention of these were entirely omitted from this report, and I accordingly present below such information concerning them as could be gleaned by personal observation and by reference to official or other reputable publications.

Since the war with France and the acquisition of Alsace and Lorraine, the German Empire, including for the purposes of this report the Grand Duchy of Luxemburg, has greatly increased its annual production of iron and steel, the payment of the large French indemnity serving to stimulate all German industries, and Alsace and Lorraine contributing about 20 blast furnaces and several large rolling mills, steel works, and foundries. But Germany had made great progress in the development of her iron resources prior to the war with France. She had shared the general activity caused by the ushering in of the age of steam and the age of railroads, each of which created a greatly increased demand for iron and its products. In 1830 Germany produced only about 100,000 metric tons of pig iron, and it was not until 1848 that this quantity was doubled, when 205,342 tons were produced. In 1862 the production reached 524,591 tons, which was more than doubled six years later, in 1868, when 1,200,188 tons were produced. In 1869, the year preceding the beginning of the war with France, the production was 1,356,965 tons. In 1870 and 1871 it was practically stationary, but in 1872, after the accession of the French provinces, it jumped to 1,927,061 tons, and in 1873 it reached a maximum of 2,174,058 tons; adding castings from the blast furnace, the production in the last year was 2,240,575 tons. The production of pig iron declined from 1873 to 1876, in which latter year it was 1,801,457 tons; including 44,888 tons of castings from the blast furnace, it was 1,846,345 tons. These statistics show more rapid progress in the building up of the German iron industry than has been made in the United States. In 1848 the latter country produced about 800,000 English tons of pig iron; and in 1873 a maximum of 2,560,962 tons was reached. The increase of production in the United States from 1848 to 1873 (from 800,000 to 2,560,962 tons) was at a ratio more than trebled by Germany in the same period (205,342 to 2,240,575 tons). As Germany has usually imported more pig iron than she has exported, and as the accession of Alsace and Lorraine

gave to her only about 230,000 tons of pig iron annually, the greater progress of Germany from 1848 to 1873, as compared with the progress of the United States, is an interesting fact, and is creditable to the enterprise and skill of the German people and to the natural resources of the empire.

The growth of the pig iron branch of the German iron trade down to 1873 was fully equaled in rapidity by other branches of iron manufacture and by the manufacture of steel. In 1848 there were within the limits of the present empire 109 foundries for iron castings, employing 5,112 workmen, and in 1875 the number had increased to 874, employing 42,134 workmen. The production of these foundries increased from 131,929 metric tons in 1862 to 524,137 tons in 1873, but declined to 436,104 tons in 1876. The quantity of steel of all kinds produced in 1848 was 9,024 metric tons; in 1862 it was 40,916 tons; in 1876, when the maximum was attained, it was 390,434 tons. The total production of the foundries, rolling mills, and steel works of Germany was 205,133 metric tons in 1848; 1,076,476 tons in 1868; 2,054,980 tons in 1874; and 1,835,224 tons in 1876. The production of iron ore in Germany in 1848 was 693,725 tons; in 1873 it was 6,177,576 tons; and in 1875 it was 4,730,553 tons.

The production of coal and lignite in Germany was 5,800,985 metric tons in 1848, and 49,550,462 tons in 1876. The highest recorded production of the United States was 47,513,235 English tons in 1875. Of the total production of mineral fuel by Germany in 1876, there were 38,454,428 tons of bituminous coal and 11,096,034 tons of lignite.

The foregoing statistics show that the German iron, steel, and coal industries have been almost wholly developed during the past thirty years, and that the iron industry proper reached the culmination of its prosperity in 1873. Germany is to-day the third in rank among iron-making and steel-making nations, Great Britain and the United States alone outranking her, while she probably ranks next to Great Britain as a coal-producing country.

A study of the resources possessed by Germany for the manufacture of iron and steel shows that they are both extensive and varied. Iron ore and coal are abundant, and the quality of each favorably compares with that of like products of Great Britain and France. The coal, which is easily mined, is equal to English and Welsh coal for generating steam, and the most of it yields good coke for the blast furnace. It is superior to that of France. The French

people deserve great credit for producing good iron with poor coal. The ore is of all varieties, and no difficulty is experienced in working it, except that which is caused by the presence of too much phosphorus in some varieties, rendering them unsuitable for Bessemer steel. There are commercial difficulties, however, which consist in the general separation of the coal and ore supplies, and in the remoteness of both from centres of consumption and from the sea-coast. The coal deposits are found mainly in Silesia and Saxony, bordering on Austria, and in Westphalia and Rhenish Prussia, bordering on Holland and Belgium. The ore mines are found in the same provinces and in others lying mainly upon the interior boundary line of Germany, including Bavaria, Wirtemberg, Alsace, Lorraine, and Luxemburg; but wherever found they are not usually associated with the coal deposits. Railroad and canal transportation, at greater or less expense, is thus rendered necessary to bring the raw materials together in the blast furnace, and to carry pig iron to foundries and rolling mills. But the location of the coal and iron ore at points remote from the sea-coast, and from each other, results in a still greater disadvantage to both the coal and iron industries of Germany, by making them, in a very large degree, the prey of foreign competition, water transportation for British coal and iron being much cheaper to German sea-ports, and to cities upon navigable rivers which flow into the North Sea or the Baltic Sea, than railroad or canal transportation to the same markets for the products of German mines and iron works. For the same reason these products are largely debarred from foreign markets into which they would otherwise find a ready entrance; and for the same reason, also, the cost of foreign ores for most of the Bessemer establishments of Germany, which are in the interior, is greatly increased beyond the cost of similar ores to British Bessemer steel manufacturers. The German iron trade at present labors under still another difficulty, in the removal, on the 1st of January, 1877, of all import duties on iron and steel. The government is, however, giving close attention to the needs of the iron and coal industries. The use of native coal by the German navy is encouraged; the cheapening of inland transportation and the increase of transportation facilities are also encouraged; and the re-imposition of duties on foreign iron and steel is certain to be decreed at an early day.

The number of blast furnaces in Germany in 1876 was 463, of which 297 were in blast and 166 were out of blast. Of the whole number of furnaces, 338 were in Prussia, and of these 172 were in

blast. The consumption of raw materials in the production of a ton of pig iron in Germany ranges from 2.5 to 2.8 tons of ore, from 2.8 to 3.2 tons of coal or coke, and from 1 to 1.5 tons of limestone. Many of the furnaces of Germany possess all the approved modern appliances, while comparatively few are wholly antiquated in style and naked in equipment. At Hof, in Bavaria, there are four furnaces owned by one company, each of which is 57½ feet high, 19 feet in diameter, and supplied with four Whitwell stoves. In 1874 two furnaces, 61 feet high, and having jointly a daily capacity of 70 to 80 tons, were put in blast at Mezieres-le-Metz, in Alsace. These furnaces were provided with all modern improvements, and have Cowper-Siemens hot-air stoves. Two out of four furnaces of Berge-Borbeck, belonging to the Phœnix Company at Laar, produced 27,982 tons of pig iron in 1875, or a daily average of 76⅔ tons. To produce this quantity of pig iron there were required 59,575½ tons of ore, 39,151 tons of coke, and 27,365 tons of limestone. Better results than these have been obtained at other furnaces in Germany, but the above figures I find to have been deemed worthy of prominent mention. There is observable a vast amount of enterprise and skill in the management of the blast furnaces of Germany. One of the coke furnaces of the Hoerde Iron Works was continuously in blast from July 3, 1855, to May 29, 1874, or almost nineteen years. German rolling mills and steel works are also mainly projected on a liberal and progressive scale. Krupp's Steel Works at Essen, in Rhenish Prussia, are well known to be the largest in the world. A recent publication enumerates 16 German iron and steel companies, each of which had either absorbed over 4,000,000 marks, or $1,000,000, or had been organized with a capital stock of this amount. One of these, the König and Laura Hütte, had a capital of 27,000,000 marks, or $6,750,000; another, the Dortmund Union, 41,400,000 marks, or over $10,000,000; another, the Donnersmarkhütte, 18,000,000 marks, or $4,500,000; another, the Phœnix, 16,200,000 marks, or $4,000,000; two others, the Hoerde and the Bochumer Verein, had 15,000,000 marks each, or $3,750,000; and yet two others, the Preussische Company of Dusseldorf and the Westphälishe Union, had over 10,000,000 marks each, or over $2,500,000. These references show the large, not to say extravagant, scale on which many of the iron and steel works of Germany have been projected.

Germany early embarked a large amount of capital in the manufacture of Bessemer steel, although from the first the unwelcome

fact was only too manifest that most of the ore suitable for its production would have to be imported, at least for some time. This disadvantage is now, however, not so great as formerly, domestic ores being mixed to a larger extent with foreign ores in the manufacture of Bessemer pig. The first Bessemer steel works in Germany were built about 1865, and in 1876 there were no less than 19 such establishments. Of these, 14 were in Prussia, 1 in Saxony, 2 in Bavaria, and 2 in Alsace and Lorraine. These 19 establishments contained 78 converters, of which 18 were embraced in Herr Krupp's works at Essen. Three additional converters, or a total of 81, were enumerated in 1877. Only 39 converters were at work in that year, and some of them not steadily. In apparent contradiction of the praise just bestowed on the iron and steel metallurgy of Germany, figures have been produced to show that the average yield of German converters when at work is only between one-third and one-fourth that of converters in the United States. This is certainly not a creditable showing for Germany, but it may be said in extenuation that the Bessemer practice of the United States is not equaled by that of any other country in the world. Even Great Britain falls far behind it. With 114 converters, a majority of which may be presumed to have been active, that country produced in 1878 only 850,000 tons of ingots; while the United States in the same year, with 22 converters, not all of which were active, produced exactly 653,773 English tons of ingots. Germany has made creditable progress in the introduction of the Siemens regenerative furnace and the Siemens-Martin process.

The total production of all kinds of steel in Germany has already been given for comparative years, the production for 1876 being 390,434 metrical tons. The exact quantity of each kind of steel which entered into this total is not at hand, but the proportion of Bessemer steel, as well as the extent to which it is displacing iron in Germany, may be inferred from the following statistics of the production of iron and steel rails in the years 1871 to 1876.

Year.	Iron Rails.	Steel Rails.	Total.
	Metric tons.	Metric tons.	Metric tons.
1871	320,619	128,406	449,025
1872	320,996	179 092	500,088
1873	385,601	186,643	572,244
1874	364,978	237,894	602,872
1875	227,976	241,505	469,481
1876	126,288	253,746	380,034

To illustrate the value of the accession to German iron resources and manufactures resulting from the acquisition of Alsace and Lorraine, the following statistics relating to their largest iron-making establishment are given as I find them in a foreign journal. They relate to the works of the Messrs. De Wendel. "Their works at Hayange have been in the possession of the family ever since the year 1705. Those at Moyeuvre were started by them in 1825, while the works at Stiring Wendel were commenced in 1846. During the year 1877 these combined works produced 467,000 tons of iron ore; 322,000 tons of coal; 145,000 tons of pig iron; 87,000 tons of puddled bars; 33,500 tons of merchant bars; 8,500 tons of sheet iron; 26,700 tons of rails and sleepers; 2,000 tons of small ironwork for railways and mines; 2,500 tons of iron wire; 1,400 tons of French nails; and 8,000 tons of general castings. It was stated that this production is considerably below that of the preceding year." The Messrs. De Wendel have in all 11 blast furnaces. At Moyeuvre were rolled the first rails for the first French railway. Both pig and bar iron are said to be produced by the Messrs. De Wendel at a lower cost than is possible at any other works on the Continent. Although the Messrs. De Wendel do not make steel, owing to the large quantity of phosphorus in their iron ores, they nevertheless have in use all the modern appliances for the manufacture of iron, including the Bicheroux and the Siemens furnaces and Lemud's mechanical puddlers, no iron being puddled by hand.

The cast steel manufactory at Essen has existed since the year 1810. It has been operated by the present owner, Alfred Krupp, since 1826, and since 1848 for his sole account. The number of workmen at the close of 1877 amounted to 8,500. The works occupy about 1,000 acres, of which about 187 acres are under roof. There are in these works 1,648 furnaces; 298 steam boilers; 77 steam hammers, the largest of all weighing 50 tons; 18 trains of rolls; 294 steam engines, aggregating 11,000 horse-power, one of the largest having 1,000 horse-power; and 1,063 machine tools. When all existing facilities are employed the works can produce in 24 hours 2,700 rails, which will lay 11⅛ English miles of track; 350 ties; 150 locomotive and car axles; 180 car wheels; 1,000 railroad springs; 1,500 grenades, etc. In one month there can be produced 304 field guns and guns of large calibre. From 1847 to 1877 more than 15,000 guns were produced at these works. The daily supply of coal and coke required is 1,800 tons. In immediate connection with the cast steel works are 35½ miles of railway; 24 locomotives;

747 cars; 80 horses; and 37⅓ miles of telegraph line, with 44 telegraph stations. At the various mines of Herr Krupp there were employed 5,300 workmen in addition to those already enumerated. These mines embrace 4 coal mines and 562 iron ore mines, including ore mines near Bilbao, in Spain. At the coal mines are 33 steam boilers and 48 steam engines, and at the iron mines are 30 steam boilers, 23 steam engines, and 2 locomotives. Four large steamers, owned by Herr Krupp, each of 1,700 tons burden, besides leased steamers, are engaged in the transportation of Spanish ores to his furnaces on the Rhine. Another steamer, of 1,000 tons burden, is being constructed. The mines in Spain which are operated by Herr Krupp can deliver 200,000 tons of ore annually. In addition to the cast steel works and the ore and coal mines, Herr Krupp operates 14 blast furnaces, at which 700 workmen are employed. Ten of these furnaces are of recent construction, each of which can produce an average daily product of 45 tons of pig iron. At these furnaces are 71 steam boilers and 48 steam engines. Herr Krupp also owns and operates at Sayner 2 small blast furnaces for the manufacture of spiegeleisen, and other auxiliary iron enterprises.

The Bochum Company, at Bochum, in Westphalia, manufactures crucible and Bessemer steel on a large scale; also steel castings and forgings, tires, axles, steel cannon, pig iron, etc. It mines its own coal and iron ore, and makes its own spiegeleisen. The Bessemer plant embraces 7 converters. Cast steel bells, made of crucible steel, have long formed an interesting specialty of the works of this company. Another specialty is the casting of steel in moulds by the method invented by Jacob Meier, its technical director, and which remained for many years the exclusive property of the company. The process of casting steel in forms for use has been perfected and largely practiced in Germany, which country may also be said to have given the greatest impetus to the use of cast steel as a substitute for iron axles and tires upon railways. Werner, at Carlswerk, is claimed to have been the first to make cast steel axles of good quality, and Krupp invented weldless cast steel tires.

Germany has been very prominent in the substitution of iron for wood in the building of cars for railroads, in the construction of permanent way for railroads, and in the construction of public buildings and dwellings, telegraph poles, props for mines, etc. The Messrs. De Wendel are running two trains of rolls constantly on iron railway sleepers, and have produced many thousand tons of them.

In the manufacture of machinery, machine tools, cutlery, edge tools, hardware, common and fine castings, and miscellaneous iron and steel products Germany showed at Vienna in 1873 that her people had not neglected the cultivation of the rare mechanical aptitudes which they are known to possess. In some specialties, as the manufacture of wire and scissors, German manufacturers have no superiors. Westphalian wire has a world-wide reputation. In Westphalia are also manufactured for domestic and foreign markets large quantities of anvils, axes, agricultural implements, tools, chains, etc. At Berlin are some of the most extensive manufactories of machine tools, locomotives and other engines, agricultural machinery, and beet-sugar machinery in the world. Germany is a large exporter of machine tools. In the manufacture of textile machinery, as of textiles themselves, Germany occupies an advanced position, and to its perfection she has contributed many inventions of her own. In the building of locomotives she has achieved great distinction, and in the supply of neighboring Continental countries she has met with much success. In twelve locomotive works in Germany over 1,000 locomotives have been built annually. At the large locomotive works of Albert Borsig (recently deceased) at Berlin 1,031 locomotives were manufactured in the six years prior to April, 1873, of which 300 were sent to Russia. This large establishment and an auxiliary establishment in Upper Silesia, under the same ownership, manufacture the pig iron, rolled iron, steel, boiler plate, axles, etc., required in the construction of locomotives, and besides supply large quantities of these articles to the German market. Siemens-Martin steel is largely made at the works in Upper Silesia. The number of workmen employed at these latter works in 1875 was 3,500, and the number of steam engines was 45, representing 4,400 horse-power. The works at Berlin are of corresponding magnitude.

M. Henri Schneider, the head of the great firm of Schneider & Company, at Creusot, in France, is credited with the following declaration before a government legislative commission, in February, 1878, concerning the German iron trade:

> There are a number of articles in which Germany competes with us with greater effect and is a more dangerous rival than England. The German makers are our chief enemies, and I attribute their formidable development to several causes. In the first place, their industry is based on excellent natural conditions. Germany possesses very considerable mineral wealth, developed under healthy conditions, quite independently of the speculations which of

late years have increased the production. In certain provinces, as, for instance, Nassau, and near Siegen, there are special kinds of ore producing a certain quality of iron under most advantageous conditions. Germany has now, too, in Lorraine, the finest deposits in the world for making iron cheaply. I think that ordinary pig iron can be made cheaper at the present time in Lorraine and Luxemburg than in any place in the world. For iron ores, imported by German makers from Spain for their important make of steel, they enjoy very advantageous sea-carriage rates, and from sea-ports the forwarding rates into the interior are remarkably low.

This is high praise from an industrial rival, but it is noticeable that English makers of iron and steel speak slightingly of "dear and bad" German iron made with ore and coal that are found at inconvenient distances, the latter alleged to be of poor quality, and the former largely phosphoriferous. But M. Schneider would hardly express his dread of German competition in French markets if he had nothing to be afraid of; and it is just possible that English manufacturers would have a higher respect for Germany's ability to supply herself with good iron and steel, at fair prices to consumers, if she were not so good a customer for Cleveland and Scotch pig iron and English bars. To Germany and Holland, (the latter almost wholly in transit for Germany,) Great Britain annually during 1875, 1876, and 1877 exported over half a million tons of iron and steel. Against the revenue policy which would continue these large importations German ironmasters and their idle workingmen not unnaturally protest, and they ask that they shall be protected by adequate duties against the advantages possessed by British ironmasters, namely, "the sea for their roadway, cheap shipping, cheap machinery, cheap coal, and the command of cheap capital." They allege that, if adequate protection had been afforded to them in late years, the excessive importations of iron and steel from Great Britain would not have been possible, and that their own industries and all other German industries would have measurably prospered.

The anomaly is here presented of France dreading the apprehended competition in her markets of German iron and steel, and of Germany protesting against the competition, already formidable and oppressive, of British iron and steel in German markets. We have here also illustrated one phase of industrial competition from which the United States is practically free, the contiguity or proximity of the territory of an industrial rival. Germany has undoubtedly suffered greatly from British competition, which was rendered pos-

sible by reason of the advantages stated and the repeal two years ago of German duties on iron and steel; while Germany herself, by reason of her acquisition of the iron-making districts of Alsace and Lorraine, and for the other reasons assigned by M. Schneider, occupies a threatening industrial attitude toward France. It seems clear that, if trade between these three countries were absolutely free from all restrictions, the German and the French iron and steel industries would both be injured, and those of Great Britain only would be benefited.

The following table will show the imports and exports of iron and steel and iron ore into and from Germany in 1876 and 1877.

ARTICLES.	1877.		1876.	
	Imports.	Exports.	Imports.	Exports.
	Metric tons.	Metric tons.	Metric tons.	Metric tons.
Pig iron	526,708	344,019	571,134	289,417
Scrap iron	14,225	19,915	12,520	16,783
Steel	5,622	16,145	3,946	17,792
Castings and common hardware	49,276	118,443	35,291	84,109
Rails	76,034	225,630	684	133,484
Bar iron	36,423	85,431	9,130	51,176
Angle iron	7,798	4,174	2,136	563
Plates and sheets	18,280	21,208	4,748	11,543
Tin plate	4,082	1,645	3,740	441
Iron and steel wire	3,181	31,791	2,742	15,801
Anchors, cables, etc	3,092	165	1,483	273
Wrought iron tubes	4,618	5,970	2,410	1,616
Small wares	603	1,527	679	1,328
Iron ore	328,184	804,037	197,537	670,882

All of the leading articles in the table show an increase in importations in 1877 over 1876, except pig iron, and in this the decline was slight. Bar iron increased from 9,130 to 36,423 tons; angle iron from 2,136 to 7,798 tons; and plates and sheets from 4,748 to 18,280 tons. The heavy imports of rails in 1877 were largely in transit for Russia. The large quantity of iron ore exported does not indicate a condition of prosperity for German ironmasters, who would have preferred to export it as manufactured iron.

The imports of coal, coke, and lignite into Germany in 1877 amounted to 4,750,943 metric tons, and the exports amounted to 5,370,692 tons. The coal and coke imported were principally obtained from Great Britain; the exports of coal, coke, and lignite were almost wholly to neighboring Continental countries.

Germany has more miles of railroad than any other country except the United States, exceeding even Great Britain, amounting at the beginning of 1878 to 18,828 miles.

BELGIUM.

The iron and steel of this small but wonderfully busy country were well represented at the Paris Exposition, again illustrating the achievements of Belgian enterprise, skill, and industry in overcoming great natural obstacles. Belgium has an abundance of coal, but it now contains but little good iron ore. Owing to this scarcity she is largely an importer of iron ore and of pig iron. These she converts into manufactured iron and steel, for which she finds her chief market abroad. Belgium, more than any other country, sustains an iron industry that is essentially reproductive, and it sustains it too by selling its products to other countries, and to some of the countries from which she derives the raw materials of manufacture. Belgium is, therefore, a workshop rather than a mine; a producer rather than a consumer. So long as she can manufacture iron and steel cheaper than other countries she will find a market for them in countries which have no such industries of their own, or do not protect those that they have. These conditions of success are not invested with the element of permanence, for countries that now take Belgian iron may learn to make their own iron or to protect their iron manufacturers who are now distanced by Belgian competition. But, dismissing the future, and having regard only to the present situation, it must be said that the Belgian iron and steel industries are to-day more generally employed than those of many other iron and steel producing countries. Those of Wales are perhaps the least employed. Wales was practically absent from Paris, but Belgium was present in force. Not many years ago Wales regarded the Belgian iron industry with indifference.

There is something amazing in the comparative prosperity of Belgian iron and steel industries, with their spare natural resources, at a time when the same industries of more favored countries are experiencing more or less depression. Its causes may be found in cheap labor, long hours, the technical education of workingmen, strict economy in administration, attention to the minutest details, and the use of the most approved labor-saving machinery. The population of Belgium is very dense, (5,000,000 in 12,000 square miles,) and the country is a hive of industry; there is no room for drones. Every man has his work to do, and he must be content with low wages, for high wages would soon end all employment by destroying the ability of Belgium to compete in foreign markets. Strikes are, therefore, exceedingly rare, but when they do

occur they soon terminate, for the government will not tolerate them. Personal economy is essential to existence. The labor of women and children is utilized. Railroads through its own territory, favorably situated sea-ports, and a trading spirit handed down from the Middle Ages aid in securing foreign purchasers for Belgian manufactures. It is thus that Belgium maintains most of her iron and steel works in operation. She utilizes all her resources; she is industrious and frugal; and she neglects none of her opportunities. Much of the distress now existing in other countries might be obviated by the practice of the same virtues, and it would not involve the lowering of wages to the Belgian standard.

As was the case at Vienna, the principal exhibit of Belgian iron and steel at Paris was made by the John Cockerill Society, of Seraing, five miles from Liége. It comprised specimens of pig iron, bar iron, rails, beams, locomotive and boiler plates, tires, axles, forgings, castings, mining machinery, locomotives, car wheels and other railroad appliances, and various other products. A 40-ton eight-wheeled freight locomotive; a 300 horse-power pumping engine; a 500 horse-power rolling-mill engine; two sets of rolls, one of which had rolled 10,500 tons of rails; and two rails, each 180 feet long, one of which had been twisted cold into four spirals, were among the noticeable features of this most interesting exhibit, which was especially rich in heavy machinery. Specimens of the Bessemer steel manufactured by this company embraced razors, knives, swords, bayonets, tools of all kinds, screws, wire, plates, and bars.

The works of the John Cockerill Society were established in 1817 by John Cockerill, an Englishman by birth, but a Belgian citizen, and were at first wholly employed in the construction of steam engines; but in 1823 the erection of a coke blast furnace was commenced, which was blown in in 1826. It was the first on the Continent. Until 1830 it was the only furnace of its kind in Belgium. Forges and a boiler shop were built in 1823 and 1824, a puddling mill in 1826, and a foundry in 1828. From 1830 to 1834 the works were closed, owing to political troubles. In 1835 the first locomotive and the first rails were made. In 1836 a second coke blast furnace was commenced, and in this and the following year other extensions were made. In 1838 John Cockerill became embarrassed, and in 1840 he died. In 1842 the works passed into the hands of the John Cockerill Society, and have since been greatly extended. The first Bessemer steel works in Belgium were erected by this company in 1862. Large purchases of iron ore mines and coal lands

and collieries have been made by it from time to time. It is a large owner of iron ore mines in Spain. The works now embrace 7 blast furnaces, with two more in course of erection; 2 large foundries; a large iron rolling mill; a Bessemer steel plant, with 8 converters, each of 7 tons' capacity, a rolling mill, etc.; a hammer mill for large forgings; a shop for small forgings; constructing shops for the manufacture of locomotives, marine and other engines, and other machinery; boiler, bridge, and ship-iron shops, etc., etc. At Hoboken, near Antwerp, the company owns and operates an extensive shipyard, at which 410 steamships, transports, monitors, and armored vessels have been built. It owns several vessels that are engaged in the transportation of iron ore. Its nominal capital stock is $3,000,000. It now employs 8,850 workmen at all its enterprises, to whom it pays $2,000,000 annually as wages. Its annual sales amount to about $8,000,000. It has in use 252 engines, and its daily consumption of fuel is about 1,100 tons. The annual capacity of the company is equal to the production of 400,000 tons of coal; 150,000 tons of native ore; 170,000 tons of foreign ore; 100,000 tons of pig iron; 6,000 tons of castings; 25,000 tons of girders, iron plates, and bar iron; 1,000 tons of steel plates; 100,000 tons of steel rails, bars, and tires; 1,500 tons of steel ordnance, car wheels, locomotive wheels, etc.; 8,000 tons of steam engines and mechanical apparatus; 10,000 tons of bridges, boilers, and structural iron; and 14 ocean or river vessels. The company has frequently rolled 365 tons of rails in 24 hours. The number of locomotives annually built is about 100; of steam engines, 70; and of machines of all kinds, 100. In the fiscal year 1877–8 the greatest activity prevailed in the Bessemer steel works, which produced 83,000 metric tons of steel, a large increase upon 65,000 tons in 1876–7. The company also made 57,000 tons of rails in 1877–8, an increase upon 45,000 tons in 1876–7. The works at Seraing cover 220 acres, and at Hoboken 22 acres. Such is a representative Belgian iron and steel enterprise.

Other iron and steel exhibits in the Belgian section, by the Angleur, Espérance, Ougrée, Sclessin, Providence, Couillet, Chatelineau, and other companies, were scarcely less interesting than that of the Cockerill Company. They embraced iron and steel rails, plate and sheet iron, bar iron, beams and girders, pig iron, iron ores, and Bessemer and Siemens-Martin steel in various forms. The display of beams, girders, and joists was very large, some of the specimens being of exceptional lengths and novel sections. The company at Angleur exhibited fine Bessemer steel castings. The

sheet iron exhibited by the Espérance Company was in all respects excellent. The ironmasters of the Charleroi district contributed a consolidated exhibit of beams, girders, rails, wire, sheets, pig iron, etc., which was very attractive. There was a good display of cast iron pipes. Locomotives and railway cars from the shops of the Compagnie Belge, of Brussels, and several other companies were among the prominent exhibits, and it may be mentioned that the building of steam engines, locomotives, and other railway rolling stock for export is a leading branch of Belgian industry, the cities of Brussels, Seraing, Liége, Couillet, Tubize, and others, being engaged in their manufacture. The display of tires, axles, locomotive springs, and other railway appliances was good. Mining machinery was another leading feature of the Belgian exhibit. A noticeable display of machine tools, engines, steam pumps, hydraulic presses, beet-sugar machinery, etc., was made by Cail, Halot & Company of Brussels. Machine tools were quite numerous in the Belgian section, and these and the heavy machinery were usually excellent. The display of iron wire, especially of gauges below No. 20, was large and creditable, and several machines were exhibited which make wire nails and tacks. But the Belgian display of general hardware, fine cutlery, small castings, edge and other tools, and agricultural machinery was neither large nor impressive. The Belgian iron and steel industries appear to have been developed most in the direction of rolling mill products and heavy machinery. The bar iron of Belgium has long been celebrated for its excellence. There were creditable displays of coke and compressed fuel. The latter was a prominent feature of the Belgian exhibit, and its manufacture in Belgium is so extensive as to have justified this prominence. Coal mining in Belgium dates from the 12th century.

The Belgian iron industry is of very great antiquity, dating from about the beginning of the Christian era. It appears to have never ceased to exist from that time until the present. At first the most primitive processes were employed, and afterwards blast furnaces and refinery forges. There was a charcoal furnace in operation at Dames, near Namur, in 1340. At the close of the 15th century leather bellows were in use for driving blast furnaces in the district of Liége. In 1560 Belgium had 35 blast furnaces and 85 forges. In 1693 a "splitting mill" is mentioned. Down to 1800 the furnaces were octagonal in form and only about 15 feet high; in that year circular furnaces were introduced; they were built 25 feet high, and the remarkable product of three tons a day was realized.

Charcoal becoming very scarce, John Cockerill was successful in 1826 in introducing the use of coke in the blast furnace. In 1830 the coke furnace in Belgium that would yield 2,000 tons of pig iron in a year was doing well. The puddling of iron and the use of grooved rolls were introduced into Belgium from Great Britain soon after the battle of Waterloo restored peace to Belgium and to Europe, the first puddling furnace in the kingdom having been erected in 1821. Belgian ironmasters have not been slow to observe and to utilize the improvements of other countries. In 1872 the Danks puddling furnace was introduced by the Societé Anonyme of Sclessin, and about the same time Lauth's three-high plate rolls were adopted by the Ougrée and Espérance companies.

Steel was first made in Belgium in 1753, but its manufacture was never largely developed until 1862, when the first Bessemer steel works in the kingdom were established. Just prior to that event, in the year 1860, Belgium produced only 3,172 tons of steel, part of which was crucible steel and part what is termed German steel. A year ago there were but three Belgian works engaged in the manufacture of steel by casting: the Cockerill Company, with 8 Bessemer converters; Rossius, Pastor & Company, at Angleur, with 4 Bessemer converters; and the Sclessin Company, at Tilleur, with a Siemens-Martin plant. Since then the Ponsard furnace has been introduced by the Societé de Thy-le-Château for the production of steel rails. The Ougrée Company is also erecting a gas furnace, with the view of making steel by the open-hearth process.

The statistics of the Belgian iron, steel, and coal industries are very full and complete. There are about 70 blast furnaces in the kingdom, 56 being the largest number that were ever in blast in one year. Only 26 were in blast in 1877, a fact due mainly to the increasing scarcity of native ore, but partly to foreign competition, and partly to the unsuitableness of domestic ores for Bessemer steel. The pig iron branch of the Belgian iron trade is therefore only moderately prosperous. The production of pig iron in recent years has been as follows: 1850, 144,452 metric tons; 1860, 319,943 tons; 1870, 565,234 tons; 1872, when the maximum was reached, 655,565 tons; 1876, 571,267 tons, the decline being gradual from 1872. The production of wrought iron, bar iron, blooms, plates, iron rails, etc., was 61,970 metric tons in 1850; 200,596 tons in 1860; 491,563 tons in 1870; 510,920 tons in 1874, when the maximum was reached; and 416,714 tons in 1876. In 1877 and 1878 there was an improved foreign demand for the products of Belgian rolling

mills, and production was slightly increased. In 1875 Belgium produced 20,440 metric tons of chains, cables, anchors, nails, etc., and in 1876 the production of castings was 80,759 tons. The production of steel was 3,172 metric tons in 1860; 9,563 tons in 1870; and 75,258 tons in 1876. Of the production in 1876, 71,758 tons were Bessemer steel, of which 65,000 tons were rolled into rails. The production of Bessemer steel exceeded 100,000 tons in 1877. In the fiscal year 1877–8 the John Cockerill works alone produced 83,000 tons of Bessemer steel. The production of steel in Belgium is steadily increasing. The production of iron ore has rapidly declined from 1,018,231 metric tons in 1865 to 269,206 tons in 1876.

The production of coal in Belgium steadily increased from 3,929,962 metric tons in 1840 to 15,778,401 tons in 1873, when the maximum was attained. There was a decline in 1874, a slight recovery in 1875, and a decline to 14,329,578 tons in 1876. To this may be added the production in the same year of about 300,000 tons of artificial mineral fuel, or briquets, which has since been increased to about 500,000 tons annually.

The Belgian imports and exports of iron ore, pig iron, manufactured iron, and steel for 1878 were as follows: Iron ore, imports, chiefly from the Grand Duchy of Luxemburg, 833,922 metric tons; exports, chiefly re-exports to France, 239,728 tons. Pig iron, imports, chiefly from England, Germany, and the Grand Duchy, 210,353 tons; exports, 5,362 tons. Manufactured iron, imports, 8,575 tons; exports, 191,062 tons. Nails and wrought iron sundries, imports, 3,409 tons; exports, 26,444 tons. Castings, imports, 2,030 tons; exports, 10,509 tons. Steel, imports, 4,992 tons; exports, 36,816 tons. These figures show a total of 229,299 tons of imports, and 270,193 tons of exports. Belgium's exports of machinery are large. Of the exports of iron and steel in 1878, no less than 58,282 metric tons were sent to Great Britain, of which over 49,000 tons were merchant iron, and the remainder was nails, rails, etc. The Belgian exports of rails have greatly declined since 1874, but the other iron and steel exports have been well maintained.

The imports of coal and coke into Belgium in 1876 amounted to 832,296 tons, Great Britain being the principal contributor, and Germany supplying a large part of the remainder. The exports in the same year were 4,399,605 tons, almost wholly to France.

AUSTRIA AND HUNGARY.

Americans do not usually associate the Austrian Empire with

the manufacture of iron and steel on a large scale, and yet these are among its most important productions, and the industries devoted to them have an honorable rank in comparison with like industries of other countries. Austria (in which I include Hungary) is the sixth among iron and steel producing countries, and she occupies no mean place as a manufacturer of machinery. As a manufacturer of textiles, glassware, and other light products of skilled industry, as a manufacturer of beet sugar, and as the liberal promoter of an extensive railway system, she occupies a position of well-deserved prominence. With internal and external peace, and perseverance in the tolerant and conciliatory policy which now characterizes the administration of her affairs, Austria may be expected to become within the next ten years one of the very first among industrial nations. That she has not been generally recognized in our country as a possible future rival in the production of iron and steel is mainly due to our lack of commercial intercourse with her people, but partly, also, to the almost total absence of Austrian iron and steel products at the Philadelphia Exhibition in 1876. When it was held the interest in international exhibitions of her iron and steel producers and of many other Austrian manufacturers appeared to have been exhausted by their splendid contributions to the Vienna Exhibition in 1873. But Austria grandly rallied in 1878 from her lethargy in 1876, and her whole display at Paris was exceedingly interesting, her iron and steel exhibits being especially large and varied.

The principal Austrian exhibitors of iron and steel and of railway material at Paris were the Austrian and Hungarian State Railway Companies, closely followed, however, by other large companies. It is a peculiarity of the iron and steel and coal industries of the empire that the government railroad companies are extensively engaged in their development and at widely separated localities; and it is also a peculiarity of these industries that the companies which were organized expressly and solely to engage in their development have their enterprises as greatly scattered as those of the railroad companies. These results have largely grown out of a spirit of speculation which was rife in Austria a few years ago, many of the speculations proving to be disastrous. The financial stringency which occurred in Austria early in 1873 was the beginning of the period of world-wide depression the end of which we have not yet seen. Large stock companies were organized to absorb and operate various consolidated small enterprises. Most of these

inflated organizations still remain in existence, but their stock has greatly contracted in value. They have served a useful purpose in stimulating the development of Austrian mineral resources, and in relieving the empire of dependence upon other countries for iron and steel and things made from them.

The exhibit of iron and steel and their products which was made by Austria embraced the same classes of heavy articles that were exhibited by France, Great Britain, and Belgium: pig iron of various grades; iron and steel rails; Bessemer and Siemens-Martin steel; spiegeleisen; crucible, puddled, and cemented steel; rolled iron for building purposes; plates and sheets; axles and tires; locomotives and other railway requisites; chilled car wheels; tubes and pipes; iron permanent way for railroads; a general assortment of heavy and light machinery, etc., etc. Joined to these were samples of fuels and iron ores. Much of the pig iron was made with charcoal, and was excellent in quality, being specially adapted to the manufacture of steel. The locomotives were among the finest in the Exposition. About 1840, when Austria began to build railroads, she adopted the American locomotive as a model, and the Austrian locomotives of to-day are very similar to those of the United States. Railroad crossings of chilled iron were exhibited by Ganz & Co., of Buda-Pesth, who also exhibited a fine collection of chilled car wheels of American style, one of which had run 329,400 miles and another 380,000 miles. It is stated that chilled car wheels have been used on the Emperor Ferdinand Railway, in Northern Austria, since 1855, and have ever since increased in number, so that now, with 10,000 freight cars, 23,140 such wheels (21,696 from Ganz & Co., and 1,444 from Count Andrassy's works at Dernoe,) are in use. Projectiles made of chilled cast iron were also exhibited by Ganz & Co. Two styles of iron permanent way were exhibited, several systems of which have been introduced upon Austrian and Hungarian railroads. Of sugar-making machinery there was a large display, but of agricultural machinery and implements the display was greatly inferior to that of France, Great Britain, or the United States. The exhibit of wood-working machinery was small. Stationary and portable engines were numerous in the Austrian and Hungarian sections. Boilers made of Bessemer steel plates were exhibited by the Emperor Ferdinand Railway Company, and good boiler plates of Bessemer steel were exhibited by the Hungarian State Railway Company. Steel armor plates were exhibited by J. Braun's Söhne, of Schöndorf. The exhibit of

wire, wire rope, and wire-work of all kinds was very extensive. Austria vies with Westphalia in the manufacture of products of this class. Car and carriage springs were shown in profusion, as were railway appliances generally. A locomotive fire-box, made of Siemens-Martin steel, with arched and corrugated sides and top, was a prominent object.

Franz Wertheim & Company and John Weiss & Sons exhibited fine collections of bench tools. The former firm also exhibited fire and burglar proof safes. Miners' tools were exhibited by Mahler & Eschenbacher. J. Braun's Söhne exhibited files. The Eisen and Stahlgewerkschaft of Eibiswald exhibited a number of circular and band saws. The display of cutlery was meagre, and very inferior to that made by Austria at Vienna. Like Belgium, the Austrian display of iron and steel and their products at Paris was notably rich in heavy articles and heavy machinery. It was not seriously deficient in small wares, the manufacture of which requires delicate manipulation or the application of delicate machinery, but they did not form one of its prominent features.

The manufacture of iron and steel in the Austrian Empire is distributed over a large part of its territory, which may be divided into three grand divisions. The most prominent of these is in the southwestern part of the empire, and embraces Styria, Carinthia, and the remaining provinces of the Austrian Alps. This district is remarkably rich in iron ores of superior quality, principally spathic, this variety being practically free from impurities, and well adapted to the production of steel, in which it is now largely employed. The spathic ores of Austria and Hungary have long been celebrated as among the best steel-producing ores in the world. In Styria and Carinthia are situated the two famous iron mountains, Erzberg and Hüttenberg, which were worked by the Romans and by the Celts two thousand years ago. In late years the Erzberg has yielded 175,000 tons of iron ore annually. Iron has been made in these Alpine provinces in furnaces of various forms of construction since the eighth century. Until the present century charcoal was the only fuel that was used, both in the furnaces and in refinery forges, but now wood, brown coal or lignite, and coke are also used. Lignite of excellent quality is found in Styria, and it is used with satisfactory results in blast furnaces and puddling furnaces. Extensive deposits of lignite which have not yet been developed are found on the line of the railroad from Vienna to Trieste. Peat is also largely used in Styrian puddling furnaces, partly in the ordinary

way and partly in connection with Siemens regenerative furnaces. True bituminous and anthracite coals are found in the Alpine provinces, but not in appreciable quantities.

The next most important division is in the northwestern part of the empire, and embraces Bohemia, Moravia, and Austrian Silesia. Iron was made in Bohemia long before the beginning of the Christian era. In some portions of this district there is good coal in large quantities, which makes an excellent coke for blast furnaces, but in others coal is scarce or impure, and lignite and wood are used. Lignite is abundant, and of good quality. Bohemia produces more than one-half of all the coal and lignite mined in the empire. The iron ores of this division are not generally so pure as those of the Alpine provinces, but included in them are some rich deposits of magnetic, specular, spathic, and red and brown hematites. Many of the ores are manganiferous. Much of the iron of this district is well adapted to foundry purposes, and it has been customary to make large and small castings direct from the blast furnace. Cupola foundries, some with hot blast, are, however, common, and usually well employed. Until quite recently charcoal has been the only fuel used in this district, and it is still largely consumed in blast furnaces and in a few bloomaries or refinery forges. Bloomaries were only a few years ago very numerous in this district, Bohemia alone having 110 in 1865, which converted into wrought iron a large part of the product of 28 blast furnaces: now, however, puddling furnaces are numerous, in 1871 there being 116 in Bohemia and 70 in Moravia and Silesia.

The third division into which the Austrian iron industry is territorially divided embraces the extensive provinces lying wholly or in part in the Carpathian mountains—Hungary, Galicia, Buckowina, Transylvania, and others. This division, like the one last named, has a variety of ores, a large proportion of them being of good quality. The development of large deposits which are known to exist in Galicia and elsewhere has scarcely been commenced, while others have been worked for centuries. The primitive wolf furnaces are still to be found in use in this district, as well as bloomaries; but charcoal and coke furnaces, rolling mills, and yet more modern processes are numerous. Charcoal is the principal fuel used in the blast furnaces. Coal is scarce, but lignite is abundant.

The first puddling furnace in Austria was built at Witkowitz, in Moravia, in 1826, and at the same place the first coke blast furnace in the empire was built in 1838. From these two events

may be dated the beginning of the modern iron industry of Austria The first coke furnace in the Alpine provinces was erected at Prewald, in Carinthia, in 1870; the first puddling furnace in Carinthia was erected in 1828. German steel made in Styria and Carinthia was celebrated for its excellence fifty years ago, when the annual production was about 15,000 tons, a part of which found its way to American markets. These provinces have also, for many years, made crucible steel of excellent quality. Puddled steel has been made in Austria since 1835, but in large quantities only since 1852. It was at one time largely used for rails. It is still made in small quantities. The first Bessemer steel works in Austria were commenced at Turrach, in Upper Styria, in 1862; there are now 13 works in the empire, with 32 converters. These works are located in various provinces, but principally in Styria. At most of the works the pig iron is run direct from the blast furnace into the converter. At the works at Reschicza, in Hungary, there are three converters, each of 9 tons' capacity; the annual product of the works is, however, only about 9,000 tons. Spiegeleisen is manufactured at several places in Austria; ferro-manganese is also manufactured in blast furnaces in the province of Carniola, and probably elsewhere. Siemens furnaces have been used in Austria since 1858, when they were introduced at Kapfenberg in connection with the manufacture of cast steel. In 1867 the Siemens-Martin process was introduced at the same place, but the manufacture of steel by this process has never been greatly extended in Austria, the earlier processes and the Bessemer process being in greater favor. The manufacture of tin-plate has been thoroughly established at several places.

As has already been intimated, there are many strong companies engaged in the manufacture of iron and steel in Austria and Hungary, and their enterprises have been projected on a scale worthy of more prominent iron and steel making countries.

The whole number of blast furnaces in the Austrian Empire in 1876 was 279, of which 166 were in blast and 113 were out of blast. The production of pig iron and castings from the blast furnace in 1840 was 144,352 metric tons; in 1850 it was 223,045 tons; in 1860 it was 348,798 tons; in 1870 it was 452,244 tons; in 1873, when the maximum was attained, it was 594,980 tons; in 1876 it was 450,933 tons. These figures show a more gradual increase in the production of pig iron than has been the experience of some other countries, and they also show a smaller proportionate decrease

in production since the culminating point was reached in 1873. The present blast furnace practice of Austria and Hungary is perhaps presented in its most favorable aspect in the record made in 1873 by two Buttgenbach coke furnaces erected by the Innerberger Company at Schwechat, near Vienna. They are each 60 feet high, 18 feet diameter at the boshes, 12 feet diameter at the top, and 7 feet across the hearth. There are two blowing engines, each of 360 horse-power. In 1873 each furnace made 50 tons of pig iron daily from 112½ tons of Styrian spathic ore, 7½ to 12½ tons of limestone, and 62½ tons of coke.

At the close of 1877 there were 17 rail mills in the empire. The course of the rail manufacture since 1870 is seen in the following table.

Year.	Iron Rails.	Steel Rails.	Total.
	Metric tons.	Metric tons.	Metric tons.
1870	89,790	17,307	107,097
1871	90,463	23,199	113,662
1872	86,556	38,009	124,565
1873	80,742	50,327	131,069
1874	54,797	57,169	111,966
1875	40,155	61,345	101,500
1876	22,819	64,491	87,310
1877	18,645	79,065	97,710

These figures indicate the same tendency to substitute steel rails for iron rails that is observable in other countries. The growth of the Bessemer steel industry in Austria has, however, been very slow. In 1864, when the first works went into operation, the production was 306 metric tons; six years later, in 1870, it amounted to only 20,722 tons, with six works in operation; in 1874 it reached 96,958 tons, with 9 works in operation; since that year the production has twice fallen slightly below 90,000 tons; but in 1877 there was an increase to 97,470 tons, with 13 works and 32 converters in existence, and 11 works and 28 converters in operation. The exceedingly small output of so many works and converters is in part accounted for by the small size of the converters, which are generally of from 2½ to 3 tons' capacity.

The production of iron ore in the Austrian Empire amounted to 573,079 metric tons in 1851, and in 1873 it amounted to 1,588,256 tons, the increase in the meantime being gradual. From 1873 to 1876 there was a steady decline in production, the figures for the latter year being 902,421 tons.

The production of coal in Austria and Hungary, the mining of which dates from the middle of the 16th century, amounted to only 94,607 metric tons in 1819, and to only 944,323 tons in 1850. In 1855 there was an increase to 2,101,050 tons; in 1865 to 5,069,303 tons; in 1870 to 8,355,944 tons; and in 1876, when the maximum was reached, to 13,362,586 tons, of which 5,564,331 tons were pit coal and 7,798,255 tons were lignite.

The imports of iron and steel into the Austrian Empire have undergone as great a change in late years as have similar imports into our own country since 1873. From 1866 to 1872 the imports of pig and scrap iron increased from 131,351 metric tons to 219,078 tons, but in 1876 the imports were only 38,057 tons. From 1868 to 1870 the imports of rails rose from 54,218 tons to 116,813 tons, but have since steadily fallen to 805 tons in 1876. The imports of bar iron have fallen from 27,880 tons in 1872 to 1,458 tons in 1876. The imports of hardware and machinery have fallen from 64,551 tons in 1872 to 20,363 tons in 1876. The imports of steel have fallen from 1,127 tons in 1871 to 880 tons in 1876.

The exports of iron and steel from Austria have increased in recent years until in many particulars they now exceed the imports. In 1875 the exports of rails amounted to 10,774 metric tons, but fell in 1876 to 4,325 tons. In 1875 the exports of pig and scrap iron reached to 10,727 tons, but fell in 1876 to 7,317 tons. The exports of bar iron amounted to 7,056 tons in 1875, and to 8,304 tons in 1876. The exports of hardware and machinery reached to 26,886 tons in 1874, but fell to 19,926 tons in 1876. The exports of steel of all descriptions have not greatly varied from 4,000 tons annually from 1866 to 1876.

The imports of iron ore have always been inconsiderable, the largest quantity having been reached in 1872, when 15,675 metric tons were imported, since which year there has been a steady decline to 2,429 tons in 1876. The exports of iron ore appear to have been highest in 1875, when the quantity amounted to 52,817 tons; in 1876 there were 38,159 tons sent out of the country.

Since 1865 the imports and exports of coal into and out of Austria have both grown steadily, owing mainly to the completion of railway communications with neighboring countries, but the exports have increased the most. In that year the imports were 366,488 metric tons, and the exports were 385,662 tons. In 1876 the imports were 1,574,575 tons, and the exports were 2,734,862 tons.

The foregoing statistics and other references appear to establish

conclusively the fact that Austria is possessed of sufficient resources to enable her to supply her own iron and steel wants, and the further fact that she is now supplying them. Recent information leads to the conclusion that the government of the empire will pursue a revenue policy that will tend at least to confirm Austrian iron and steel manufacturers in the possession of the home market.

RUSSIA.

Russia ranks seventh among iron-producing countries, and her exhibit of iron and steel products at Paris was worthy of her rank. Although the iron industry of Russia is not of recent origin, having existed long before the days of Peter the Great, two centuries ago, it has not been characterized by a progressive spirit nor by notable activity until within the past few years. The present Emperor, Alexander II, has given to it greater encouragement and a greater impetus than any one of his predecessors. This he has done by a variety of measures, including a protective tariff, bounties to special manufactures, and the extension of railroad communications. It will be a long time, however, before all the widely-separated parts of his vast empire will be joined together with iron bands, as the United States is now joined, and in the meantime it is too much to expect that Russia, wise as her ruler is, and enterprising as her ruling classes are, will be able to fully utilize her scattered mineral resources. She is not wanting in iron ore, nor in fuel to smelt it and to refine the iron obtained from it; but she is largely wanting, because of the vastness of her territory, in the means necessary to bring the fuel to the ore and the iron to a market. It is, therefore, all the more to her credit that she has made even limited progress in the development of her iron resources, and that her iron and steel makers were enabled to make the fine display they did at Paris. The Russian iron and steel exhibit was one of the most valuable and most interesting in the Exposition. It was mainly composed of articles which charcoal and not mineral fuel had produced, a fact suggestive of immense possibilities, for, if such progress could be made with a fuel which has never yet fully developed the iron resources of a single country, not even excepting Sweden, what may not be possible when her extensive deposits of mineral fuel come generally into use as an addition to the vast quantities of charcoal which the boundless Russian forests are yet capable of supplying when they shall be penetrated by Russian railroads?

The principal exhibitor in the iron and steel department of the Russian section was Prince Demidoff, whose extensive works in the Ural mountains, where he owns a million and a half acres of forests and mineral lands, have long been noted. He is a large manufacturer of pig iron, finished iron, and Bessemer and other steel. The Russian Government works and several private companies were also well represented. The entire exhibit embraced samples of magnetic and other iron ores of extraordinary richness and purity; fine samples of charcoal pig iron; and a full assortment of bar iron, sheet iron, plates, rods, iron wire, axles, tires, car wheels, iron and steel rails, Bessemer and Siemens-Martin steel, crucible and puddled steel, projectiles, swords, chains, etc. Prince Demidoff showed Bessemer steel boiler plates of excellent quality; also Bessemer steel rails 45 feet long, and another steel rail, 50 feet long, which had been twisted cold; also plates and rods of Siemens-Martin steel, some of which had been bent and broken to show their quality; also a disc of the same kind of steel, $\frac{3}{4}$ of an inch thick, and 7 feet 5 inches in diameter. The same exhibitor also showed a variety of steel tools, scythes, swords, etc. Several kinds of steel, all of excellent quality, were shown by several exhibitors, with fine effect. The Imperial Technical School of Moscow made a good display of tools, as did also a few other exhibitors. The display of cutlery was not large, but it was remarkably good, and indicated not only the possession by Russia of the best of steel but the possession also of the best of skill in its manipulation. The knives, forks, scissors, and swords exhibited were not surpassed in excellence by any similar display. Hackman & Co., a Finnish firm, of Wiborg, were prominent among the Russian cutlery exhibitors. In their works they employ 90 men. In machine and other castings the Russian section was not far behind the best of its competitors, but in heavy machinery, agricultural implements, and railroad appliances it was deficient in extent and variety. The Industrial Society of Varsovie exhibited a collection of car couplings, car springs, and wrought iron car wheels. A few steam engines of creditable workmanship were exhibited, as were detached parts of engines, well made and exquisitely polished. Much of the engine work was produced by the pupils at the Industrial Schools of Moscow and St. Petersburg. Messrs. Lillipop, Rau & Loewenstein, of Varsovie, exhibited beet-sugar machinery. Specimens of the bituminous and anthracite coal of Russia were exhibited, the former of various qualities, and the latter said to analyze 90 per cent. of carbon.

The iron and steel industries of Russia may be said to have the whole empire for their home, for they are found in many parts of it —in the Ural mountains in the east, in the Donetz mountains in the south, in the vicinity of Moscow in the centre, in Poland and neighboring territory in the west, and in Olonetz and Finland and at St. Petersburg in the north. The Ural mountains produce more than half of the pig iron annually made in Russia, and a large part of the finished products. At and near St. Petersburg is displayed the greatest localized activity in the production of rails, plates, steel, and some other finished products. Bessemer steel is now made successfully at three or four establishments in the empire, and open-hearth steel is made at many places in Siemens-Martin and Pernot furnaces. Crucible and puddled steel of good quality have long been made. Chrome steel, from native ores, is made at the Obouchoff Steel Works, near St. Petersburg. Siemens regenerative furnaces are common. Spiegeleisen is successfully made in Finland and in the Ural mountains. Russian ores are of various qualities, magnetic, specular, brown and red hematites, etc. Some ores are taken from the bottom of bogs and lakes, and they are found in quantities which are practically inexhaustible. No other country in Europe is better supplied with good ores than Russia, not even Sweden and Spain. The magnetic mountain of Blagodat, in the Ural mountains, is one of the richest and most remarkable iron ore deposits in the world. It has been worked for 140 years.

At Kolpino, near St. Petersburg, on the railroad leading to Moscow, extensive works have recently been erected for the manufacture of boiler and ship plates, armor plates, beams, angles, bars, and other iron for use in the government ship-yards and in the construction of government buildings. At Alexandrovsky, near St. Petersburg, are situated the Obouchoff Steel Works, at which heavy steel guns are manufactured from crucible cast steel. Ingots of steel weighing 40 tons and upwards have been cast at these works, each 40-ton ingot requiring the use of 1,200 crucibles. An 80-ton gun was made here a few years ago, the ingot for the breech-block of which weighed nearly 50 tons, and was hammered into shape under a 50-ton hammer. Most of the crucibles are heated with imported coke, but Siemens gas furnaces supply heat to others. A Bessemer converter, of 5 tons' capacity, has been in use for several years. These works make weldless tires, wheels, axles, shafts, boiler plates, etc., for Russian railroads, all of Bessemer or open-hearth steel. They were established about twenty years ago, and now

employ 2,500 men. Near St. Petersburg is the largest rail-making establishment in Russia, the Poutiloff Works, which produces annually about 16,000 tons of rails and 4,000 tons of steel tires and other finished products. At these works Bessemer converters have been in use for several years and a large Siemens steel plant has been erected. There are connected with these works four charcoal furnaces and a rolling mill in Finland. On the Neva, five miles from St. Petersburg, is a large plate and merchant bar mill, and a shipbuilding yard, owned by the Russian Engineering and Mining Company, with a capital of about $5,000,000. This company built the *Grand Admiral* a few years ago, the engines for which were supplied by a St. Petersburg firm. The armor plates for the Russian imperial frigate, the *Duke of Edinburgh*, were, however, made at the Motala Works, in Sweden. At Briansk, on the Orel-Witebsk Railway, a large mill for rerolling iron rails, and for the manufacture of iron bridge-work, was started in June, 1874. The Imperial Gun Foundry at Perm, in the Ural mountains, is an extensive establishment, which has long been engaged in the manufacture of cannon and projectiles, musket barrels, and other warlike material. It has recently been greatly enlarged. Steel has long been manufactured here in crucibles, and a Pernot furnace is now in use. At Kama the Jjeff's Arms Factory is employed in the manufacture of needle guns, and crucible steel is here made with Siemens gas furnaces, charcoal being used as fuel. At the Nijni-Salda Iron Works of Prince Demidoff a very complete Bessemer plant was added in 1875. The converters are of 5 tons' capacity, and the metal is run into them direct from blast furnaces specially constructed for this purpose. A new rolling mill, with a 350 horse-power steam engine, has been added to the one previously in use. The machinery for these improvements was largely manufactured at Nijni-Taguil, where some of Prince Demidoff's works are located, and where a Siemens-Martin plant has recently been erected, with a capacity of 32 tons of steel daily. Spiegeleisen is made at Taguil.

The New Russia Company, founded by Mr. John Hughes, owns blast furnaces and rail mills in Donetz Valley, Southern Russia. A Siemens-Martin steel plant has recently been erected at these works, and the Russian Government has lately given the company orders for steel rails aggregating 43,225 tons. In Southeastern Russia are located the various iron enterprises of the Vyksounsky Company, an English organization, which possesses four hundred thousand acres of forests and mineral lands, and carries on the iron

manufacture in many of its branches, making pig iron, bar iron, tires, hoops, plates, sheets, telegraph and other wire, nails, steam engines and other heavy machinery. The works of this company are greatly scattered. At Huta Bankowa, in Russian Poland, are four blast furnaces and a rolling mill, which are reported to have passed into the hands of a French company that proposes to add a steel plant, with which it expects to make steel rails, tires, axles, and other railway material. In the Nijni-Novgorod district new iron works were established in 1875, by Jonooskopf & Mendeleieff, consisting of a blast furnace, 42 feet high, blown with a horizontal engine, puddling and reheating furnaces, and a train of merchant rolls. In April, 1876, a new establishment for the manufacture of wrought iron pipes was started at St. Petersburg. The great central market for the sale of iron in Russia is Nijni-Novgorod.

Many of the iron and steel works of Russia are owned in whole or in part and directly or indirectly managed by the government. Some of the enterprises already mentioned are thus owned and controlled. A few others may be mentioned, some of great antiquity. In the district of Blagodat, in the province of Perm, are situated the Kushwinsk blast furnaces, commenced in 1735; the Verkhni-Turinsk furnaces, which date from 1737; the Baranchinsk furnaces, which date from 1743; the Nijni-Turinsk iron works, founded in 1766, and which produce annually about 2,200 tons of bar and sheet iron and boiler plate; and the Serebranskii works, established in 1784, which make about 800 tons of finished iron, 1,000 tons of puddled iron, and 650 tons of steel annually. The Serebranskii works are driven by ten water wheels, and have four Siemens furnaces and three trains of rolls. At the Knase-Michailovski works, in the mining district of Zlatoust, province of Ufa, is a very extensive manufactory of cannon and small arms, founded in 1771, which includes a steel department, of large and varied capacity. The Satkinsk works, in the same district, established in 1756, produce pig iron. The Watkinskii works, founded in 1759, annually make about 1,000 tons of wrought iron, 100 tons of chains, 1,000 tons of rails, and 500 tons of steel. The Kamskii works, in the province of Perm, founded in 1862, annually produce about 500 tons of armor plates, and other heavy iron for shipbuilding purposes, and employ 850 workmen. In Olonetz and Finland are the Alexandrovskii works, founded in 1772, which constitute a gun and projectile foundry; the Koncheoserkii furnace, dating from 1707; the Suojarvi furnace, owned by the government since 1856; and the

Valaasminskii furnace. These furnaces use lake or bog ore, as do most of the Finnish furnaces. At Slawkaw, in Russian Poland, are government works which produce sheet iron; and at Panki, also in Poland, is a government blast furnace.

In addition to the various iron and steel enterprises here enumerated there are other extensive works in the Ural mountains, in Finland, and elsewhere, but sufficient details have been given to show the progress that Russia has made in the introduction of modern processes of iron and steel manufacture. Her pig iron was eagerly purchased by England and other countries two centuries ago, because of its exceptional excellence, and her sheet iron, made by a process peculiarly her own, has long challenged the admiration of the world.

The accessible statistics of the iron and steel industries of Russia do not come down to a later period than 1875. In that year there were produced 426,896 metric tons of pig iron and furnace castings from 913,607 tons of iron ore; 243,126 tons of bar iron, rails, etc.; 60,693 tons of plates and sheets; and 12,928 tons of steel. The quantity of iron ore mined in 1875 amounted to 1,063,831 tons. In 1866 the production of iron ore was 581,771 tons. In 1830 the production of the blast furnaces amounted to 183,104 tons; in 1860 to 297,937 tons; and in 1870 to 359,989 tons. In 1860 the production of wrought iron was 183,735 tons, and in 1870 it was 251,582 tons. In 1860 the production of steel was 1,051 tons, and in 1870 it was 8,788 tons. The production of iron ore, pig iron and castings, wrought iron, and steel, respectively, was greater in 1875 than in any preceding year. In 1873 there were in Russia 245 blast furnaces, 522 puddling furnaces, 700 reheating furnaces, 20 puddling and reheating furnaces, 840 refinery furnaces, 472 steel furnaces, 191 cupolas, and 88 air-melting furnaces. In 1876 the number of blast furnaces in Finland was 21. In this district and in other portions of Russia the furnaces are small, and at nearly all of them water-power is used. With scarcely an exception, charcoal is used as fuel. A great deal of iron is still refined in Russia in Catalan forges and bloomaries, and by other primitive methods. The fuel used is charcoal, and power is obtained from the mountain streams.

The mining of coal in Russia is mainly confined to the districts of Donetz, Vistula, and Moscow, although coal is found in several other localities. The Donetz district is in the Donetz mountains in Southern Russia, and is one of the most extensive in Europe; it

contains both anthracite and bituminous coal, much of it of good quality. The Moscow district is in Central Russia, and the Vistula district is in Russian Poland. The total production of all the coal fields of Russia was 437,625 metric tons in 1867, and 1,709,269 tons in 1875. Of the production in 1875, the Donetz district yielded 842,558 tons; the Moscow district, 387,538 tons; and the Vistula district, 407,935 tons. The methods employed in the mining of Russian coal are not usually the best that science and economy would suggest, but that great progress is being made in its development is shown in the greatly increased production from 1867 to 1875. Incomplete statistics for 1876 show a production in that year approximating 2,000,000 metric tons. The coal in the neighborhood of Moscow is largely lignite, but of good quality.

The imports of iron and steel and of machinery into Russia are large, indicating that, if there has been over-production of these products in other countries, there has certainly been none in this. In 1875 there were imported, principally from Great Britain, 57,464 metric tons of pig iron; 87,705 tons of bar iron; 58,126 tons of iron rails; 111,554 tons of steel rails; 31,031 tons of hoops, sheets, etc.; 3,813 tons of plates; and 19,638 tons of steel. Since 1875, however, the iron and steel industries of Russia have been greatly stimulated, and the imports of 1875 have not been maintained, although still large, owing to the pressing exigencies created by the war of 1877–8 with Turkey. In 1878 four iron vessels and forty locomotives were purchased in the United States. This country has also supplied large quantities of agricultural implements to Russia, but Great Britain has been an active competitor in this field. The imports of coal into Russia amounted to 1,497,214 metric tons in 1876, Great Britain, Germany, and Austria supplying all. The Finnish furnaces are partly supplied with ore from Sweden.

If the published statistics of Russian exports are correct, the exports of iron amounted to 14,062 metric tons in 1876, and to 1,145 tons in 1877, while the exports of steel amounted to 71 tons in 1876. The exports of coal in 1876 amounted to only 565 tons.

SWEDEN.

This most interesting country made a splendid display at Paris of its iron and steel resources, as it has done at all recent international exhibitions. No better iron is made in the world than is made by Sweden, with native ores and charcoal fuel, and, having

to rely mainly upon other countries to consume what she produces, she would have been faithless to her own interests if she had not exhibited samples of this iron upon every suitable occasion. But she has not been satisfied merely to exhibit these samples; she has arranged them with the utmost taste and care, giving them a really artistic embellishment, which has not, however, imparted to them a gaudy and offensive prominence; and, to still further heighten the effect and add to the value of their display, she has distanced all her rivals in the enterprise and tact she has shown in printing and circulating, in many languages, exhaustive descriptions of her metallurgical resources, of the methods employed in their utilization, of the capacity of her manufacturing establishments, and of the character of their products. No American who visited the Philadelphia Exhibition can forget the Swedish iron and steel exhibit, or the great work of Professor Akerman, which was freely distributed, "On the State of the Iron Industry in Sweden." At Paris similar taste and similar enterprise were displayed. The Swedish iron and steel exhibit was in every respect magnificent. The display of Swedish machinery and tools and cutlery was also very creditable, but it was not large. The machinery display was not so large as that of Belgium, which is a much smaller country and lacks Sweden's metallurgical resources.

The Swedish iron and steel exhibit comprised all the raw materials and finished products the country produces. The well-known Motala Company was the principal exhibitor. There were many specimens of the rich magnetic, specular, hematite, and other ores of the country; specimens of pig iron, spiegeleisen, bar iron, rods, wire, billets, and nails; Bessemer, crucible, and Siemens-Martin steel; steel and iron plates; wrought iron car wheels, etc. Some of the specimens were twisted, bent, and fractured to show their quality. The Swedish Iron Board showed Bessemer and Siemens-Martin plates and also iron plates, all of which had been subjected to comparative tests which established the superiority of those made of steel. In machinery there were various wood-working machines of ordinary excellence; a Bessemer steel marine boiler; a couple of vertical engines, and a few other good engines. J. & J. C. Bolinder, of Stockholm, exhibited saw-mill machinery, circular saws, and a large collection of stoves and furnaces. The display of agricultural implements and machinery was neither large nor noteworthy; but a better display could not, perhaps, have been justly expected, as Sweden is not greatly favored in its agricultural capa-

bilities. The articles exhibited were not, as a rule, light and graceful and "handy," like their American rivals. In tools generally Sweden showed to better advantage, and in knives, razors, scissors, and other cutlery there was a small but creditable display. Of railway appliances the display was small, and not specially remarkable. It is a fair criticism of the entire Swedish exhibit of iron and steel to say that the quality of the articles shown was not excelled in the Exposition, and that in extent and variety they were excelled only by Great Britain, France, and Belgium; and it is also a fair criticism of the machinery, tools, and other iron and steel articles exhibited to say that they indicated that Sweden has not made the same progress in the reproductive arts associated with the iron and steel manufacture that has been made by Great Britain, the United States, France, Germany, Belgium, and Austria. A stranger can not well understand why a people so intelligent and skillful as the Swedes, and possessed of their resources, should have so generally limited their energies to the production of crude or half-manufactured iron and steel products, excellent and unsurpassed as they are.

The principal iron ore deposits of Sweden are found in the district lying immediately north of lakes Wenner and Wetter, and northwest of Stockholm. Here are located a majority of the blast furnaces and finished iron and steel establishments of Sweden. The ores found in this district are principally magnetic. Iron ore is, however, found in almost all parts of the kingdom, and in Lapland there are immense deposits of magnetic ore which have remained practically undeveloped because there has been no great scarcity of good ores elsewhere in Sweden. The rock or mountain ores of Sweden are almost free from phosphorus, and many of them are rich in manganese. They are therefore well adapted to the production of Bessemer steel, in the manufacture of which Sweden was the first country in the world to win complete success, but in which she has not recently borne a prominent part. The pig iron intended to be converted into Bessemer steel is produced in charcoal furnaces, and from them is run direct, without exception, into the converters, which are of from 2 to 4 tons' capacity. The ore and the fuel both being of the best quality, the steel produced is in every respect superior. I am reminded by Professor Akerman that at the Paris Exposition of 1867 Sweden exhibited the finest razors and similar wares of Bessemer steel, and that in the manufacture of cutlery in Sweden this metal is now almost exclusively employed. At the Bessemer

steel works powerful blowing engines are used, and with one exception (Sandviken) they are all driven by water-power. The early converters are all stationary, but a majority of the Bessemer works have movable converters. Some of the ores used in the production of Bessemer steel are so rich in manganese that the addition of spiegeleisen in the converter is not necessary. This is also prominently the case with the Altenberg spathic ores which are used in the manufacture of pig iron by the Neuberg works in Styria, in Austria, and from which the celebrated Neuberg Bessemer steel is obtained. Such spiegeleisen and ferro-manganese as are needed in the manufacture of Swedish steel are easily produced.

The magnetic and specular ores of Sweden, called mountain ores, are appropriated to the production of wrought iron and steel, and the ores found in the lakes and bogs, which are chiefly obtained in one province, (Småland,) are mainly used in the production of foundry iron. The latter ores contain phosphorus. The blast furnaces of Sweden were built about 30 feet high until within the last few years; modern furnaces are from 40 to 55 feet high, and from 7 to 10½ feet wide at the boshes. Pine and spruce charcoal is almost exclusively used as fuel in the blast furnaces, wood and brushwood being sometimes mixed with it, and occasionally a little coke. It need scarcely be added that the Swedish method of preparing ores for the furnace and the subsequent treatment of them are painstaking in the extreme, securing great excellence and uniformity of product. The production of the furnaces ranges from 30 to 120 tons a week. Almost without exception blast is supplied by water-power. Wrought iron is usually obtained by refining pig iron in Lancashire hearths, and subsequently hammering or rolling the blooms. The Lancashire process was introduced from England about 1830 by Gustaf Ekman, a distinguished Swedish ironmaster. The Franche-Comté process, which is a modification of the Lancashire process, is used at some of the smaller works, and at still other works, in Dannemora, the Walloon process is used. Other refining hearths may yet be found in Sweden, but are not much used. All these are but modifications of the ordinary bloomary process. Catalan forges, for the reduction of ore directly to wrought iron, have been abandoned in Sweden, but the other methods, just mentioned, which have been generally superseded by puddling furnaces in other iron-making countries, are still popular with the Swedes. In the Lancashire, Franche-Comté, and Walloon processes charcoal is the only fuel that is used. Puddling is done at only a few works, chiefly with

imported coal, but air-dried pine wood is used at two works, and at Motala and Surahammar regenerative gas furnaces for peat have been successfully introduced.

German steel has long been made in Sweden, and small quantities are still made. Puddled steel is made at two works. The manufacture of steel in crucibles by the Uchatius method is in operation at Wikmanshyttan; crucible cast steel is also made at Österby, in a Siemens-Lunden furnace, with wood as fuel. Since 1868 the open-hearth process has been in use at Munkfors, where the works of the Uddeholm Company are located, and since that year other works have adopted it. A Pernot furnace has been erected at Boxholm. In 1876 there were 19 Bessemer works in Sweden, but some of them were not then at work, and the producing capacity of nearly all of them was small.

The primitive methods of iron manufacture which have been mentioned have become deeply rooted in the affections of the Swedish people, and partly to this preference, partly to the absence of mineral fuel for the generation of steam and for other purposes, partly to the absence of restrictive duties on foreign iron and steel and iron and steel products, and partly also to the scarcity of capital and the insufficiency of railroad and canal transportation, may be attributed the slow progress made by Sweden in increasing the production of her iron which was famous for its excellence before a pound of iron was made in the United States, and even before prophecy had foretold for England her marvelous career in supplying the world's demand for iron and steel. These primitive methods are so generally adhered to to-day that, even if the other influences named were essentially modified, the production of iron and steel in Sweden would not increase very rapidly. A few large coke furnaces, supplied with fire brick hot blast stoves and powerful blowing engines, would double the production of pig iron, but they will not soon be built, although coke might easily be obtained from England or Germany. One Bessemer establishment such as we have in the United States would double the production of Bessemer steel, but the Swedes have no present use for it. Quality not quantity is their motto, and it is a good one; but they might have both if they would. They ought, at least, to have supplied their own iron and steel wants, which, remarkable as it may seem, they have not done for many years.

The works of the Motala Company are the most important in Sweden. They comprise five distinct establishments: (1) the

works at Motala; (2) the Motala ship-yard at Norrköping; (3) the Lindholmen ship-yard and machine shops; (4) the Nyköping works; (5) the Bängbro iron and steel works. Plates, bars, tires, gun bands, railway wheels, locomotives, castings, and Bessemer and Siemens-Martin steel are among the products of the various works. The Motala is a limited company, with 800 shares, the aggregate par value of all of which is about $1,100,000. In 1874 there were paid by this company for labor and materials about $2,000,000, exclusive of the Bängbro works. Other large works are those of the Fagersta, Sandviken, Surahammar, and Uddeholm companies.

Very few iron rails are made in Sweden, and still fewer steel rails. There is but little local demand for the latter, and they can not be manufactured so cheaply as to permit of their exportation. The iron rails used are chiefly imported, the Swedes preferring to put their good iron into other forms and buy "cheap" British and Belgian iron rails, upon which they impose no duty. It may be safely assumed that so long as this policy is continued neither the iron nor the steel rail trade of Sweden will prosper. Before 1870 no rails of any kind were made in Sweden. Wrought iron railway wheels; railroad axles of steel and iron; steel tires; nails, wire, and other iron and steel products are manufactured in small quantities; but here again production and prosperity are less than would exist if import duties were higher than they are. In the manufacture of locomotives and railroad cars Sweden does not supply her own wants.

In the southwestern part of Sweden, opposite "The Sound," in a district of country of which Helsingborg is the principal town, is found the only coal deposit thus far discovered in the kingdom. The coal is of an inferior quality, and the annual product has never amounted to 100,000 metric tons; it was 92,352 tons in 1876. It seems probable that Sweden will never greatly increase this product, but British and German coal are so near at hand that the absence of native coal is not a serious drawback to those industries on or near the sea-coast which require mineral fuel in the production of steam, or are otherwise best promoted by its use. The imports of coal and coke are annually increasing. In 1855 they amounted to only 135,652 metric tons; in 1876 they had reached to 946,092 tons, Great Britain supplying almost the entire quantity. Since 1876 Germany has made a determined effort to supply the Scandinavian countries and Russia with her Westphalian coal.

The production of iron ores in Sweden was 417,337 metric tons in 1860, of which 395,111 tons were mountain ores, and 22,226 tons were lake and bog ores. In 1874 the production was 926,825 tons, when the maximum was reached, of which only 4,300 tons were lake and bog ores. In 1876 the production of mountain ores fell to 787,461 tons, while that of lake and bog ores increased to 9,000 tons. The exports of Swedish ores are mainly to Finland, amounting to 25,310 metric tons in 1874, and in 1876 to 14,920 tons. The imports of iron ore are only nominal, amounting in 1874 to only 191 metric tons, probably from Norway.

In 1875 there were 325 blast furnaces in Sweden, of which 224 were in blast, and 101 were out of blast. In 1876 there were 205 in blast, which produced 344,834 metric tons of pig iron. The production of pig iron in 1860 was 179,897 metric tons; in 1870 it was 293,253 tons; and in 1873 it was 339,685 tons. The production of castings from the blast furnace has increased since 1860, when it was 5,237 metric tons; in 1876 7,788 tons were produced. In 1875 there were produced 17,331 tons of castings in 61 foundries; 189,845 tons of wrought iron were produced with 770 furnaces and fires in 33 works; and 21,385 tons of Bessemer, open-hearth, and other steel were produced in 33 steel works, of which 19,370 tons were Bessemer steel. The total production of rails in 1875 was 2,893 tons; of plates and sheets, 9,077 tons; of wire and nails, 8,313 tons; of tools, 1,847 tons; of "other hardware," 16,-110 tons.

The imports of iron and steel, machinery, tools, and cutlery into Sweden, principally from Great Britain, aggregated 88,355 metric tons in 1875, of which 55,099 tons were rails, and 17,924 tons were pig iron. The total value of the imports was £1,628,386, of which £824,938 represented "machines and tools," not including steam engines and edge tools. In 1875 the imports of iron and steel amounted to 65,893 tons, of which rails formed just one-half. The exports of iron and steel, etc., from Sweden in 1875 amounted to 204,752 metric tons, of which 106,393 tons were bar iron; 48,742 tons were pig iron; 12,439 tons were blooms; 20,049 tons were hoop, bulb, and "other iron;" and 6,273 tons were "raw steel." The value of the exports was £2,512,549. In 1876 only 174,862 tons were exported. It is plain that Sweden does not derive the benefits from her valuable iron resources that she might. She imports almost half as much iron and steel and their products as she exports, and pays for the articles she imports more than half

the money she receives for her exports. Greater diversification of her mechanical industries, greater persistence in those for which she possesses special facilities, a wider acceptance of modern metallurgical methods, an increase of her 2,500 miles of railroad to at least 5,000 miles, and a protective tariff are the great needs of the iron and steel industries of Sweden.

UNITED STATES.

The United States is the last to be mentioned of the eight countries named in a preceding table which produce more than ninety-eight and a half per cent. of all the iron and more than ninety-nine per cent. of all the steel made in the world; but it is the second in rank among these countries.

As has been already stated, the whole display made by the United States at Paris was inadequate and not fairly representative of the industrial resources and progress of our country. This remark is especially applicable to the display of iron and steel and their products. The great rolling mills and steel works of the country literally made no sign of their capabilities, and our equally great blast furnaces and machine shops were scarcely represented, and our cutlery and tool manufactories but partially. It is not merely a familiar rhetorical pleasantry to say that the products of all these establishments were conspicuous by their absence, for their presence in force had been expected, and with reason. The Philadelphia Exhibition had taught the world that the United States had developed unsurpassed enterprise, and skill, and resources in the production of all kinds of iron and steel, and machinery, cutlery, and tools, and surely it was not to have been expected that the manufacturers of these products would so generally ignore another world's fair two years later. To be more specific, it may be frankly stated that absolutely nothing was exhibited by the various steel works of the country, nor by the rail, bar, plate, sheet, hoop, and wire mills. Not a rail, nor a bar of iron, nor an ingot of steel of American manufacture was on exhibition, and only a few kegs of cut nails. The large locomotive works of the United States were represented by one locomotive; the manufacturers of steam fire engines sent only one engine; the manufacturers of machine tools sent almost nothing; there was but one exhibit of pig iron and but two or three exhibits of iron ores; no American railway freight car was on exhibition; there was but one exhibit of American anthracite

coal, and none whatever of our unequaled Connellsville coke. Of bituminous or semi-bituminous coal from the great coal basins of the country West Virginia made the only display. We sent but few stoves, although we make the neatest, cheapest, and best stoves in the world. An unpleasant subject may be dismissed with the summary statement that a great opportunity to deepen the good impression made at Philadelphia by our iron and steel manufacturers, and by our manufacturers of heavy machinery, and of cutlery and tools, and to reap the fruits of that impression, was almost wholly lost at Paris—lost because our own government delayed too long the acceptance of the invitation by the French government to participate in the Exposition, and because when the invitation was accepted sufficient money was not appropriated to enable manufacturers to make a proper display of their products.

The Barnum Richardson Company, of Lime Rock, Connecticut, made a very fine exhibit of Salisbury iron ores, charcoal pig iron, and chilled car wheels. Samples of the pig iron and some of the car wheels were broken to show their quality. Some of the Salisbury wheels of exceptional excellence have made the following mileage record on the Lake Shore and Michigan Southern Railroad: 4 wheels averaged 185,049 miles; 2 averaged 220,528 miles; 2 others averaged 198,967 miles; 3 averaged 189,397 miles; 6 averaged 175,-203 miles; and 4 averaged 168,979 miles. The Lobdell Car Wheel Company, of Wilmington, Delaware, also made a very creditable display of chilled car wheels, and of chilled iron rolls for calendering paper and for other manufacturing purposes. The company also submitted printed statements showing the amount of service performed by some of the wheels of its manufacture. One wheel had been twenty-five years in service on the New York and Erie Railroad, and is supposed to have run a million miles; other wheels had been in use on the Philadelphia, Wilmington and Baltimore Railroad over twenty years, but their mileage is not known. From 50,000 to 80,000 miles is a common record for the Salisbury and Lobdell car wheels to make. The paper-making rolls exhibited by the Lobdell company attracted great attention; they were smooth and perfectly true, and the chill was of a depth with which European founders are unfamiliar. They were polished like silver. Whitney & Sons, of Philadelphia, exhibited chilled car wheels of their make which suffered nothing by comparison with the exhibits of the other manufacturers mentioned. Some of the wheels were broken, to show the quality of the iron and the depth of the chill.

A wheel was exhibited by this firm which had traveled 120,000 miles under the tank of a locomotive and was fit for further service. Chilled car wheels are not a novelty in Europe, but they are not generally in use, except perhaps in Austria, and it was gratifying to see three of our leading car-wheel manufacturers so mindful of the opportunity presented to them at Paris to add to the popularity of American wheels. Our exports of these wheels may be largely increased with a little effort.

Samples of iron and steel produced by the direct process of C. M. DuPuy, of Philadelphia, were exhibited by Philip S. Justice, of the same city. Mr. DuPuy has since been called to Europe to explain his process. Morris, Wheeler & Co., of Philadelphia, exhibited samples of their cut nails; and Hoopes & Townsend, of the same city, exhibited complete and handsome samples of their nuts, bolts, screws, rivets, and washers. The nuts manufactured by this firm are made by machinery and punched cold, and are perfect in every respect. Machine-made horse-shoe nails, bright and well proportioned, were exhibited by the Globe Nail Company, of Boston. Aiken & Drummond, of Louisville, Kentucky, exhibited an ingenious machine for making moulds for all kinds of fine and other metal castings. Scales for mines, foundries, furnaces, rolling-mills, railroads, and miscellaneous uses were exhibited by the Fairbanks and the Howe scale companies of Vermont, and formed the finest display of the kind at the Exposition.

The American display of machinery and machine tools was not large, as has already been stated. Very heavy mining, excavating, lifting, and manufacturing machinery was wholly wanting, but the model of a machine for mining coal was exhibited by the Lechner Mining Machine Company, of Columbus, Ohio. No machinery whatever for making iron or steel was exhibited. Of cotton, woolen, and silk manufacturing machinery the only exhibits were the Jacquard loom of Tilt & Son, of Paterson, New Jersey, and a circular loom for weaving multiply fabrics, exhibited by J. V. D. Reed, of New York. There were several steam engines, of various forms of construction, on exhibition, and, as already stated, one locomotive—the last exhibited by the Philadelphia and Reading Railroad Company, which also exhibited the only sample of American anthracite coal I observed at the Exposition. An engine of the Corliss type, with improved valves and valvular arrangement, was exhibited in motion by Jerome Wheelock, of Worcester, Massachusetts, and attracted much attention from experts. A sample of bituminous coal

from the Indian Territory and other small samples of the same kind of coal from the Pacific Coast were exhibited. Among the machine tools exhibited was the Blake stone and ore crusher, and a very fine collection of the machines of the Brown & Sharpe Manufacturing Company, of Providence, Rhode Island. Bliss & Williams, of New York, and the St. Louis Stamping Company also made noticeable displays of their stamping machines, and the former firm exhibited other metal-working machines. In the class of railroad apparatus there were exhibited, in addition to the articles already mentioned, samples of car springs, by the National Car Spring Company, of New York; a street railway car, by J. G. Brill, of Philadelphia; three cars of the same description, by the John Stephenson Company, of New York; one model of a sleeping car and one full-sized sleeping car, by the Pullman Palace Car Company, of Chicago; and automatic air brakes, by the Westinghouse Air Brake Company, of Pittsburgh. The Collins Company, of Hartford, Connecticut, and the Douglas Axe Manufacturing Company, of Boston, exhibited axes, hatchets, and other edge tools which justly received much attention, and were in the highest degree creditable to our country. Several firms exhibited carpenters' tools, and other firms exhibited garden tools and agricultural implements, such as rakes, hoes, shovels, forks, etc. Oliver Ames & Sons, of North Easton, Massachusetts, made a fine display of shovels and spades. The excellence of American rakes, hoes, forks, shovels, etc., is everywhere recognized in Europe, where many of them are in use. Files and rasps were exhibited by McCaffrey & Brother, of Philadelphia; and the Russell & Erwin Manufacturing Company, of New Britain, Connecticut, showed a full collection of its celebrated specialties. Tacks and nails were exhibited by A. Field & Sons, of Taunton, Massachusetts; and pumps, hydrants, hydraulic rams, etc., by W. & B. Douglas, of Middletown, Connecticut. The only display of American saws was made by Henry Disston & Sons, of Philadelphia, and it not only elicited the hearty praise of all who saw it but it was generally recognized as the best exhibit of the kind at the Exposition. J. A. Fay & Co., of Cincinnati, Trump Brothers, of Wilmington, Delaware, and others, exhibited wood-working machinery. Machines for making boots and shoes, for crimping leather, and for sewing were exhibited, and served to illustrate not only the inventive genius of the American people but the extensive use which their general adoption of labor-saving machinery has created for iron and steel in the United States.

The display at Paris of American agricultural machines—mowers, reapers, threshers, binders, etc.,—was in all respects creditable. It is not my province to enter into particulars concerning it, or concerning the triumphs of American agricultural machines at the competitive trials which took place in France during the summer; but I could not pass without notice such a magnificent collection of labor-saving inventions, to the neatness, completeness, lightness, and success of which American iron and steel have so greatly contributed.

Imperfect and unsatisfying as was the American mechanical display at Paris, it nevertheless was sufficiently meritorious to elicit from that great exponent of European and especially English public opinion, the London *Times*, the highest measure of praise. Whole columns were devoted by it last summer to eulogizing American mechanical genius and its productions. It may not be inappropriate that I should close my reference to the American display at Paris by quoting from the *Times* of August 22, 1878, the following brief paragraphs.

Finest type of the Yankee contrivance is the Stow "flexible" shaft for transferring power round corners and to out-of-the-way places. One sees the operator holding what seems at first sight to be a small garden hose, but furnished with an auger at its extremity, with which he thrusts and bores in every direction—over his head, under his feet, to the right, to the left—it upsets all one's ideas of rigidity. Pharaoh could not have been more surprised at seeing Moses' rod turn to a serpent than we were to see this rope-like affair eating into the planks set on all sides for it to work on. It is as good as a piece of legerdemain. It is really a "flexible shaft"—a cable of steel wires wound coat over coat, each successive coating in the reverse direction from the preceding, until the strength required is attained, and in which longitudinal flexibility is combined with circumferential rigidity.

Close by it stands Clough & Williamson's "wire cork-screw machine," which catches a straight piece of steel wire and throws it out a cork-screw of such temper that it may be driven through an inch deal plank and not yield a hair's breadth. The deftest waiter will take as long to pull a cork as this machine to make half-a-dozen cork-screws of an exceptionally good quality.

Here is a screw-cutting machine, which takes a rod of iron, steel, or brass, and by an automatic series of operations drops screws at the other end of the machine. One tool cuts the point of the rod down to the dimensions of the screw, another cuts it off, having the head the full size of the rod, another takes it from the last and passes it on to have the thread cut, a cutter passes by and leaves it slotted, another with four iron fingers takes it and transfers it to a fifth cutter, where the head is finished, when still another tool comes to push it into the pan placed to receive it. No intervention is needed until another rod is wanted.

A set of shoe-making apparatus in another enclosure takes the leather in the hide and turns out, with slight manual application, a pair of shoes, sewed, pegged, or screwed, in about 15 minutes.

The manufacture of iron in the colonies which now form the Atlantic portion of the United States commenced immediately after their first settlement by the English about the beginning of the 17th century. At first bog ores were used, and, although other and more valuable ores were soon afterwards discovered and used, it is worthy of remark that the use of bog ores continued in New England down almost to the middle of the present century. The first iron enterprise in the colonies was undertaken on Falling creek, in Virginia, in 1619, but it ended disastrously in 1622, the Indians destroying the works, which were most probably forges. This enterprise was not revived. In 1643 a blast furnace was successfully established at Lynn, in Massachusetts, and in 1651 a forge was added at the same place. Soon afterwards other iron enterprises were established in Massachusetts, Rhode Island, and Connecticut. About 1734 the development of the celebrated Salisbury iron ore district of Connecticut was commenced by Thomas Lamb, who erected a forge at Lime Rock. Soon after 1664 iron was made at Shrewsbury, in New Jersey, by Henry Leonard, and in 1682 it is recorded that a forge and blast furnace were in existence at this place. Experiments in the manufacture of iron in Pennsylvania date from 1692, but iron was not successfully made until 1717, when Thomas Rutter built a forge on Manatawny creek, near Pottstown. Other iron enterprises in Pennsylvania soon followed. About 1715 the manufacture of iron was revived in Virginia at Fredericksburg and commenced in Maryland at Principio, in Cecil county. The Carolinas made iron about the same time. Iron was made in New York about 1740, on Ancram creek, in Columbia county. No iron was made in Georgia until the present century.

Early in the 18th century the exportation of iron from the colonies to England commenced, the scarcity of timber for charcoal preventing that country from making a large quantity of pig iron. Small quantities of bar iron were shipped in 1717 and 1718, and were followed by other shipments down to the Revolution. In 1728 and 1729 the colonies exported 1,156 English tons of pig iron to England, and annually thereafter down to the Revolution pig iron was regularly exported to England and Scotland. The shipments of bar iron and pig iron never reached large proportions, aggregating only about 50,000 tons of bar iron and 150,000 tons of pig

iron from their commencement to the Revolution. The iron industry in the colonies was, however, so fully established that it supplied the home markets, which was a more important matter than the building up of a great export trade. When the war for independence came, success would have been impossible if the colonists had not been able to supply themselves with home-made iron for all warlike purposes.

When the war for independence was over, the American iron industry took a fresh start in many of the States, especially in Pennsylvania, and many furnaces and forges were built, charcoal being the only fuel used. But the general use of coke in the blast furnaces of England, and the introduction in the same country of puddling furnaces and grooved rolls, and the application of steam to rolling mills and blast furnaces, about this time wrought a great change in the English iron manufacture, and through these improvements and the very low duties levied in this country on all imported iron England was enabled to contest with considerable success the possession by the States of their own iron markets. This formidable foreign competition had the effect in time of greatly retarding the development of the domestic iron industry. Notwithstanding the steady development of the country in other directions, its iron industry made but slow progress. In 1810 the total production of pig iron was only 54,000 tons, and of bar iron only 24,541 tons. In 1820 the production of pig iron had fallen to 20,000 tons; but in 1828, owing to the passage in 1824 of a high tariff, it rose to 130,000 tons, and in 1832, in consequence of the continuance of the policy of 1824, it reached 200,000 tons. But in 1833 a reactionary tariff policy was adopted, which continued until 1842, in which year the total production of pig iron was but slightly in excess of that of 1832, being 215,000 tons. From 1842 to 1846 high duties again prevailed, and in the latter year the production reached 765,000 tons. To this increase the influence of mineral fuel, which had been recently introduced, in part contributed. In 1846 duties were again reduced, with the result that, notwithstanding the use of mineral fuel, for a year or two production remained stationary and then commenced to fall, dropping in 1852 to 500,000 tons. From this time forward until 1860 the iron industry of the country very slowly advanced, despite the continued adherence of the government to a policy of low duties. It was fortuitously aided by the discovery of gold in California and Australia, which quickened business and commercial enterprise throughout the world;

by the Crimean war, which created a sudden demand for British iron and advanced its price; and by the rapid growth from 1850 to 1860 of the railway system of the United States. Notwithstanding these favorable influences, the production of pig iron only increased from 500,000 tons in 1852 to 821,223 tons in 1860. Protective duties were restored in 1861, but the depressing influences of the civil war in that and the following year reduced the production of iron below that of 1860. In 1863 and 1864 the wants of the government and the beneficial influences of the tariff of 1861 unitedly caused a production of 1,014,282 tons of pig iron in the latter year, from which there was a decline during 1865, when the war closed. After 1865 the production of all kinds of iron, and of steel also, rapidly increased, the stimulating effects of the tariff of 1861 being now everywhere perceptible, but the abundance of money and the fever for building railroads forming yet more potent influences in securing this increase. In 1872 the production of pig iron reached the very large quantity of 2,548,712 tons, and in 1873 even this product was slightly exceeded, 2,560,962 tons being then produced. But from 1873, when the financial and railroad panic occurred, until 1876 the production of pig iron gradually declined to 1,868,960 tons. In 1877 it increased to 2,066,593 tons, and in 1878 the production was about 2,300,000 tons. With the steadiness in the currency which is now assured, and a continuance of the protective policy which has been in force since 1861, the production of pig iron and of all kinds of iron and steel must continue to increase with the growth of the country in population and in general prosperity. The imports of iron and steel have fallen to merely nominal figures within the past few years, while our exports of these products and of articles manufactured from them is slowly increasing. The American consumers of iron and steel have never been supplied with these products at such low rates as are now charged—a result due wholly to home competition.

The manufacture of iron in the United States is now established in twenty-nine out of thirty-eight States, and in two Territories and the District of Columbia. The manufacture of steel is established in seventeen States. In each of the years 1877 and 1878 Pennsylvania made just one-half of the total production of pig iron, and about 45 per cent. of all the rails produced. Her production of all kinds of rolled iron in these two years was about 40 per cent. of the total quantity rolled. In the manufacture of steel Pennsylvania has annually for several years produced more than one-half of the total

product. Ohio is a large producer of pig iron, her annual product being about 400,000 tons. New York is the next most important pig iron producing State. In the manufacture of iron and steel rails Illinois is the second and Ohio the third State in the Union. The manufacture of crucible steel in the United States is mainly confined to Pittsburgh, in Pennsylvania, New Jersey being the next most important seat of this industry. Open-hearth steel is made in eight States, from New Hampshire to Tennessee. There are eleven establishments in the United States for the manufacture of Bessemer steel—one in New York, five in Pennsylvania, one in Ohio, three in Illinois, and one in Missouri; all of these except the last were in operation in 1878. Michigan is the leading iron ore producing State, the product in 1878 being 1,125,231 tons. Fully one-third of all the pig iron produced in the United States is made from Michigan ores. New York, New Jersey, and Missouri have each yielded large quantities of iron ores for shipment to other States, as well as for use by local iron works. Virginia, Tennessee, Georgia, and Alabama have also furnished ores for shipment to other States. The iron ores of the United States embrace all the varieties that are needed in the manufacture of iron or steel, but it is proper to say that the manganiferous iron ores of the country, although existing in various localities, have not yet been fully developed, necessitating the importation of considerable quantities of spiegeleisen and ferro-manganese, for use in the Bessemer and open-hearth processes; also of Spanish and Mediterranean iron ores. Of coal there is an abundance, and, like the ores, it is well distributed. Of neither iron ores nor coal will the United States ever be in want.

The production of iron and steel in the United States in 1877 was as follows in English tons: Pig iron, 2,066,593 tons; iron rails, 296,910 tons; Bessemer steel rails, 385,865 tons; all rolled iron, not including rails, 1,021,624 tons; crucible steel, 36,098 tons; open-hearth steel, 22,349 tons; puddled and blister steel, 10,646 tons; Bessemer steel ingots, 500,524 tons. The production of Bessemer steel and of Bessemer steel rails greatly increased in 1878, the former amounting to 653,773 tons, and the latter to 491,427 tons. In 1867 the production of Bessemer steel rails was only 2,276 tons. The production of open-hearth steel increased in 1878 to 32,255 tons. Included in the rolled iron produced in 1877 were 4,828,918 kegs of cut nails and spikes, each of 100 pounds' weight.

The number of blast furnaces in the United States is now 700, of which not quite 300 were in blast in 1877 and 1878. These were

generally the largest and best furnaces, the small and old-fashioned furnaces not being able to make iron at present prices. The number of rolling mills in the United States (separate establishments which have one or more trains of rolls) is 340, containing 4,463 single puddling furnaces, double furnaces being counted as two single ones. The number of Bessemer steel works is 11, each having two converters, the capacity of all the converters varying from five to seven tons at each blow. The number of open-hearth steel works is 14, with a united annual capacity of about 90,000 tons. The number of crucible and other steel works is 46, with an annual capacity of about 100,000 tons. There are yet in operation in the country 64 Catalan forges, for the direct conversion of iron ore into wrought iron; these forges are mainly in New York and Tennessee, and in the former State they are wholly engaged in the production of iron for the manufacture of steel. Pig iron is converted into blooms in 58 bloomaries, which are mainly located in Pennsylvania.

Down to 1835 all the pig iron manufactured in the United States was made with charcoal. In that year pig iron was successfully made with coke at a charcoal furnace in Pennsylvania, and in 1836 coke was successfully used at another charcoal furnace in the same State. Other furnaces in Pennsylvania commenced to use coke soon afterwards. In 1837 a furnace was built in Alleghany county, Maryland, expressly to use coke, and in 1840 two other furnaces were built in the same county for the same purpose; all were successful in the use of the new fuel. In 1837 anthracite coal was successfully experimented with in charcoal furnaces in Pennsylvania in the manufacture of pig iron, and in 1838 a furnace was built at Mauch Chunk, in Pennsylvania, to use this fuel; this experiment was also successful. But the most satisfactory experiment with anthracite coal was made with the Pioneer furnace at Pottsville in 1839, soon after which anthracite furnaces became quite numerous in Pennsylvania, New Jersey, and Maryland. Bituminous coal in its raw state was first used in a charcoal furnace in Mercer county, Pennsylvania, in 1845, and in 1846 it was successfully used in the Lowell furnace, in Mahoning county, Ohio, which was built specially for the purpose. In 1877 there were produced with anthracite coal 834,640 tons of pig iron; with bituminous coal, raw or coked, 948,165 tons; and with charcoal, 283,788 tons.

The Bessemer process for the manufacture of steel was introduced into the United States in 1864 and 1865, and the first steel rails

were made in the latter year. In 1865 the first Siemens gas furnace was built in the United States, at Pittsburgh, to melt copper, and in 1867 the Siemens furnace was successfully applied to the manufacture of iron and steel at various places. The Siemens-Martin process was successfully introduced into the United States by Cooper, Hewitt & Co., in 1868, at their works at Trenton, New Jersey.

Complete statistics of the production of coal in the United States have not been compiled for a later year than 1875, when 47,513,235 tons were produced, of which 20,654,509 tons were anthracite; 26,031,726 tons were bituminous; and 827,000 tons were post-carboniferous. The production of bituminous coal is believed to have increased since 1875, but that of anthracite was less in 1878 than in 1875.

The imports into the United States in the fiscal year ended June 30, 1878, were 55,000 English tons, chiefly spiegeleisen, valued at $1,250,057; 30,359 tons of bar, sheet, plate, and other rolled iron, valued at $1,627,052; no iron rails; ten tons of steel rails, valued at $530; machinery valued at $628,667; steel ingots, bars, etc., valued at $1,220,037; cutlery, files, saws, and tools, valued at $1,295,764. To show the favorable change that has taken place in our imports of iron and steel, it may be stated that in the fiscal year 1872 there were imported into the United States 247,528 tons of pig iron, valued at $5,122,318; 129,811 tons of bar, plate, sheet, band, hoop, and scroll iron, valued at $6,900,521; 421,755 tons of iron rails, valued at $15,778,941; 109,781 tons of steel rails, valued at $6,277,694; machinery, valued at $1,054,045; steel ingots, bars, etc., valued at $4,033,508; cutlery, files, saws, and tools, valued at $3,269,143. The exports of domestic products from the United States in the fiscal year 1878 included 5,781 tons of pig iron, valued at $140,148; 10,990 tons of bar, sheet, plate, and railroad iron, valued at $482,908; 98 locomotives, 103 stationary engines, and other machinery and boilers, valued at $5,096,857; 70 tons of steel ingots, valued at $15,892; and cutlery, edge tools, files, and saws, valued at $1,005,689. The imports of iron ore for the fiscal year 1878 aggregated 29,765 tons, valued at $62,787. In the fiscal year 1877 they were valued at $82,947, and the tonnage was estimated to have amounted to 41,473½ tons. In 1878 iron ore valued at $662 was exported. In the fiscal year 1878 there were imported 578,457 tons of coal, principally from Nova Scotia, Vancouver's Island, and Australia, and 660,138 tons were exported, of which 319,477 tons were anthracite and 340,661 tons were bituminous.

COUNTRIES WHICH MAKE BUT LITTLE IRON AND STEEL.

The countries which unitedly make less than one and a half per cent. of the world's production of iron, and less than three-fourths of one per cent. of its production of steel, may be enumerated as follows: Norway, Spain, Portugal, Italy, Switzerland, Greece, Turkey, Algeria, Morocco, Central and Southern Africa, India, China, Japan, Afghanistan, Persia, Australasia, British America, Mexico, and the States of South America. Some of these countries, it is well known, will never produce much iron or steel, and the limited resources which they possess for their manufacture need not therefore receive much attention in this report; others, however, possess ample resources, and the extent to which they have been developed, or are likely to be developed, whether illustrated at Paris or not, may well receive consideration.

Beginning at the north of Europe is the first of the countries above mentioned, *Norway*. Its iron industry dates back several centuries, but it never reached a position of commanding importance, and it is now at a very low stage. In 1870 there were produced 21,155 Norwegian tons of iron ore; 3,975 tons of cast or pig iron; 845 tons of wrought iron; and 265 tons of steel. The Norwegian ton is equal to 2,200 English pounds. In 1861 the production was as follows: iron ore, 24,385 tons; cast or pig iron, 7,575 tons; wrought iron, 3,895 tons; steel, 65 tons. The production of iron ore appears to have reached its maximum in 1865, when 49,720 tons were mined. The exports of iron ores, principally to England, increased from 335 tons in 1861 to 15,115 tons in 1870. Since 1870 the production and exportation of iron ores are said to have increased, but statistics are wanting. The exports of Norwegian iron amount to about 2,000 tons annually, and the imports to about 20,000 tons. The Baldwin Locomotive Works, of Philadelphia, have recently concluded a contract to supply four locomotives to Norway.

There are 42 rolling mills, nail factories, foundries, machine shops, etc., in Norway. Iron ore is not so abundant as in Sweden, and what there is is not well developed. The iron industry of Norway is not so productive as it was a hundred years ago. The causes of this decadence may be found in the climate, the scarcity of forests of timber suitable for the manufacture of charcoal, the great demand for timber for exportation, the entire absence of mineral fuel, and the poverty of the people. What little iron is made in

Norway is excellent; it is all made with charcoal. Steel is made at only one establishment, the Naes Iron Works, where blister steel is first made by cementation and then melted in crucibles. It is not improbable that the iron and steel industries of Norway may some day take a fresh start, but they can never form an important factor in supplying the world's demands for these products.

Norway made at Paris a small but fitting display of her iron resources and of her progress in the manufacture of machinery and tools. The iron ores, and the iron itself, of Norway were illustrated by several fine samples. Jacob Aall & Son, of Naes, showed several specimens of iron ores, cast and bar iron, raw and crucible steel, several cast steel cannon, and a collection of axes, hammers, files, and other tools. Plows, straw-cutters, and other agricultural implements, none possessing extraordinary qualities except strength, were exhibited; also several small engines. The Koaerner Works exhibited machine-made horse shoes. Visitors to the Philadelphia Exhibition in 1876 will remember the unique and ingenious iron trophy, erected by the Cathrineholm Iron Works, representing an ancient Norway ship, full rigged and equipped, the whole composed of iron in appropriate forms. This ship was not exhibited at Paris.

Spain is very richly endowed with iron ores of the best quality, and she possesses coal with which she might smelt these ores, but Spain has almost wholly neglected her opportunities, and instead of being an exporter of iron and steel she is an importer of these articles and an exporter of iron ores, while her coal remains practically undeveloped. These results are the more surprising because anterior to the Christian era Spain was a manufacturer of iron. The sword blades of Toledo were celebrated during the Middle Ages. Catalan forges were so named hundreds of years ago from Catalonia, a province of Spain. But a change has recently taken place in public opinion in Spain in favor of the encouragement of domestic manufactures, the government giving special encouragement to the mining of coal by requiring domestic coal to be used in the Spanish navy. The apathy and lack of capital of the Spanish people, and their need of a more extended railroad system, will, however, tend to retard the rapid multiplication of iron works and coal mines in Spain.

The iron and steel exhibit made by Spain at Paris was surprisingly large and creditable. Four exhibits were especially noticeable—those of Duro y Compañia Langres la Felguera, in the Astu-

rias; of Don Ybarra, of Barracaldo; of the Fabrica de Quiros; and of the Fabrica Nacional de Trubia. These exhibits embraced pig iron and iron ores; bar, rod, sheet, plate, and shaped iron; iron rails; and puddled steel. Don Ybarra showed also samples of iron sponge made by the Chenot process. Jauragui, of Zorroza, showed some samples of wrought iron and cemented steel. The celebrated ores of Bilbao were well represented. Of the manufactures of iron and steel which were exhibited by Spain, mention may be made of a few good castings, of sabres and other cutlery and edge tools, of portable and stationary engines, and of agricultural and other light machinery, the whole forming an interesting display. The principal iron ore deposits of Spain lie on the northern coast, in the vicinity of Bilbao, but very promising mines have also been opened in the south of Spain, among which may be mentioned those of Palomares, in the Gulf of Vera, province of Almeria. Most of the Spanish ores are admirably adapted to the manufacture of Bessemer steel, and Great Britain, France, Belgium, Germany, and the United States are importers of them. The production of iron ores in Spain in 1877 was 1,162,170 metric tons, of which over 1,000,000 tons were exported to Great Britain, France, Germany, Belgium, and the United States.

Except Catalan forges, which are still in use in many provinces, the manufacture of iron and steel in Spain is confined to a few establishments, and these are chiefly in the northern part of the country. The works of La Felguera comprise 4 blast furnaces, 24 puddling furnaces, 10 reheating furnaces, 3 steam hammers, 39 steam engines, and a complete forge and rolling mill plant. They have an annual capacity of 20,700 tons of pig iron and 14,000 tons of rolled iron, including 5,000 tons of rails: puddled steel is made in small quantities. The works of Don Ybarra comprise 3 blast furnaces and a well-appointed rolling mill. There are a few other blast furnaces and one or two small rolling mills. The total production of iron in Spain in 1877 was about 100,000 metric tons, of which about 40,000 tons were wrought iron, and 60,000 tons were pig iron. Pig iron is made in part with charcoal and in part with coke. The Duro Company, of La Felguera, has Belgian coke ovens at Vega, and employs machinery for washing the coal. The production of steel in Spain was only 216 metric tons in 1873. The first blast furnaces in Spain are said to have been erected near Marbella, on the Mediterranean, in 1828.

The imports of iron and steel into Spain in 1875 were as follows:

pig and scrap iron, 19,008 metric tons; rails, 11,360 tons; plates, sheets, etc., 5,904 tons; hardware of iron and steel, 5,483 tons. In 1874 there were imported 40,251 tons of bars, hoops, etc., and 3,222 tons of steel. In 1877 Great Britain exported to Spain 33,237 English tons of iron and steel. Of Spanish iron and steel exports statistics are wholly wanting, and probably there are no such shipments to be recorded.

The production of coal in Spain in 1876 was 706,814 metric tons, and the imports, chiefly from Great Britain, were 774,770 tons. The coal of Spain has been almost wholly developed since 1830, when 10,524 tons were mined. The principal development has been in the northern part of the country. No exports are recorded. The number of miles of railroad in Spain is about 4,000.

Portugal possesses both coal and iron ore in considerable quantities, and companies have recently been formed for their development. Two blocks of iron ore, showing very excellent analyses, were exhibited at Paris by the owners of the iron mines at San Thiago. This company was established by English and French capitalists in 1877, with a capital of $140,000, and its mines are advantageously situated in the province of Alemtejo. Small quantities of iron are made by a few forges in the mountains of Portugal. The production of coal in Portugal is said to have amounted to 12,387 metric tons in 1872, since which year there are no statistics. In 1876 the exports of iron ore amounted to 21,568 tons. At Paris there were several pieces of machinery and specimens of cutlery exhibited by Portugal, which showed mechanical skill of a high order.

Italy is a country of considerable manufacturing enterprise. Unfortunately there is scarcely any coal in her territory, and this want has prevented the complete development of her iron industry. She has an abundance of iron ores, and on the island of Elba they are of unsurpassed richness. The iron ores on this island and in other parts of Italy were used long before the Christian era. There are three principal iron districts in Italy additional to Elba—Lombardy, Piedmont, and Tuscany. In all Italy there are about 40 blast furnaces, many of which, owing to the scarcity of fuel, have not recently been in operation. Catalan forges for smelting iron ore and bloomaries for refining pig iron are largely used in Italy, their number being about 200. Charcoal is the principal fuel used in the furnaces, forges, and bloomaries, the Appenine forests furnishing the most of it. There are four furnaces in Italy that were built to use British

coke. In 1862 works for the manufacture of cemented steel were established at Naples, and since that date Siemens furnaces have been introduced at works in Lombardy and elsewhere for puddling iron and steel and for melting steel in crucibles. There are no large rolling mills in the kingdom. Owing to the scarcity of fuel, most of the ore mined in Italy is exported, the quantity annually sent out of the country exceeding 200,000 tons. The annual production of pig iron ranges from 20,000 to 25,000 tons, and that of wrought iron is about 50,000 tons. The production of steel in 1876 was 2,800 tons. In the same year the imports of iron and steel into Italy were as follows: pig iron, 22,535 metric tons; castings, 5,352 tons; rolled iron, 93,713 tons; iron and steel rails, 40,227 tons; steel, 4,853 tons. The exports of iron and steel are only nominal. The quantity of coal imported in 1876 was 1,454,542 tons, of which Great Britain furnished much the larger part. It will be observed that Italy is a large purchaser of iron, steel, and coal. Steel rails are coming into general use on Italian railroads, the length of which is about 5,000 miles. Throughout the country are many foundries and machine shops, cutlery works, etc., and at Naples is an establishment which has produced in the last fourteen years 142 locomotives, 72 boilers for old engines, 463 passenger cars, 2,190 freight cars, and several bridges and viaducts, foreign iron and steel being generally used.

Italy made a creditable but not extensive display at Paris of machinery, edge tools, files, railway material, iron ores, etc., but none of her exhibits call for special notice. As a manufacturer of hardware, cutlery, tools, castings, steam engines, locomotives, and similar products Italy is rapidly attaining a respectable rank, but no probability exists that she will within any reasonable limit of time make all the iron and steel her people need.

Switzerland is not noted as a manufacturer of iron or steel. The country contains three charcoal furnaces and one coke furnace, which make annually about 3,500 tons of castings and 4,000 tons of forge pig iron. The latter is converted in charcoal forges into wrought iron. There are also a few small rolling mills, which are supplied with pig iron from other countries. Iron ore is abundant in Switzerland, but coal is scarce. The Swiss have given much attention to the manufacture of cutlery, tools, and machinery, and at Paris their display of these articles was the subject of much favorable comment. Several fine steam engines were exhibited, and some small hydraulic engines. Several firms exhibited files of superior workmanship made of imported steel, and there was also a small but

handsome collection of pocket knives and fine cutlery. Of machines and machine castings there was a good display, and this also may be said of locomotives and all railway appliances. Of the latter there were seven exhibitors, including the Aarau Works, which exhibited a locomotive weighing twenty tons, intended for heavy grades.

In 1877 Switzerland imported 20,279 metric tons of pig iron and raw steel; 14,504 tons of bar iron; 11,487 tons of iron and steel rails and railway sleepers; 8,113 tons of plates; and 22,000 tons of miscellaneous iron and steel products. Her exports of these commodities are inconsiderable. The annual imports of coal average about half a million tons. Switzerland has about 1,400 miles of railroad.

Greece contains very rich iron ores on the island of Seriphos, some of which have been exported, but it contains no iron works that are now in use, except perhaps a few forges. About 1870 an attempt to smelt these ores with native lignite resulted in failure. A collection of Greek ores was exhibited at Paris and some specimens of Greek machinery. Coal and lignite are mined in small quantities in Greece. There is no immediate probability of any increase in the production of either iron or coal. The country consumes but little iron.

Turkey produces in charcoal furnaces and by primitive methods in Bosnia and Servia, and in the Lebanon mountains and elsewhere in her European and Asiatic territory, about 40,000 or 50,000 tons of iron annually. The fuel used is wholly charcoal, and the iron ores are of good quality. Coal is mined on the southern shore of the Black Sea, and the annual product is about 150,000 tons. Coal and lignite have been discovered in other parts of the empire, but like everything else of a desirable nature in that country they await development. The production of iron need not be expected to increase until more coal is mined and more railroads are built, as the supply of timber for charcoal is rapidly being exhausted in the neighborhood of existing iron works. Iron ore is abundant. Some of the Turkish iron is equal to the best Swedish. In 1877 Turkey imported 217,643 metric tons of coal, and imported from Great Britain 7,406 tons of iron and steel. Turkey in Europe contains about 1,000 miles of railroad, Turkey in Asia about 250 miles, and Roumania about 800 miles.

Algeria is noted for its rich iron ore deposits, which have been worked by French capitalists for about thirty years. The principal mines are those of Mokta-el-Hadid, near the port of Bona, and their

product in 1877 was 370,810 tons. The company which owns the Mokta mines also produced in the same year 121,852 tons of coal, the greater part of which was exported. The Beni Saif iron ore mines, worked by the Soumah Company, are the next most important in Algeria, of which there are fourteen in all. From all the iron ore mines of Algeria there were exported 466,026 tons in 1875 and 455,314 tons in 1876. The exportation of Algerian ore is not increasing, although there is no apparent limit to the supply if underground workings be resorted to. Pig iron is made at one furnace near Bona, with native coal and coke. In *Morocco* good iron ore is found, but it is undeveloped.

In *Central Africa* the natives have long made warlike and other implements of iron by simple but very effective processes. Hammers and chisels, swords, daggers, spear-heads, and arrow-heads are made of a quality deserving the highest praise. Their chains are said to be equal to the best English steel chains. *Southern Africa* possesses in the Transvaal extensive deposits of iron ore and coal, samples of which were exhibited at Paris. Some progress has been made in mining coal, but none in mining ore. Coal has also been found in Cape Colony, in the Free State of Orange, and in Natal. Madagascar is said to contain both iron ore and coal. All the territorial divisions of *Western Africa* are said to be rich in iron ores.

India has made iron and steel by primitive methods from the earliest ages. Iron ore is found in various localities, and so also is coal. The government of the country, aided by British capitalists, is doing much to develop both of these sources of wealth, several companies having been organized to mine coal and manufacture iron. Many of these enterprises are now in operation, and all of them are said to promise successful results, but for many years to come India must remain a large importer of both coal and iron. In 1877 Great Britain sent 229,421 tons of iron and steel and 894,174 tons of coal to British India. The country produces about 500,000 tons of coal annually, and has 7,599 miles of railroad.

China has an abundance of good iron ores and equally good coal, both anthracite and bituminous, all well distributed. The iron ores have been but slightly developed, only the most primitive methods for smelting and refining them being in use, blast furnaces having scarcely an existence. Coal is mined on a scale somewhat extensive for a country that has made such little use of modern mining appliances. It is estimated that the annual production of coal in China is about 3,000,000 metric tons, of which 1,000,000 tons are anthracite.

The quantity of iron annually produced can not even be estimated, but it almost equals the wants of the country, as China imports but little iron or steel. At Paris there were exhibited by China some very fine samples of wrought iron, made from magnetic iron sand, and apparently equal to Swedish iron. A collection of plows, sickles, shears, and other tools and implements showed that the Chinese are not very expert in the manipulation of iron. Some samples of coal were exhibited. Apparently but little progress in the development of either their iron or coal resources may be expected from a people who have just destroyed the only railroad within the boundaries of their extensive empire. If the locomotive could be introduced into every Chinese province the manufacture of iron would soon become an important Chinese industry, and the mining of coal would be greatly increased. In 1875 China imported from Great Britain 59,332 metric tons of coal and 1,529 tons of coke. Statistics of the imports of iron and steel are wanting.

Japan, as is well known, is a progressive country, and is rapidly adopting all the arts of modern civilization. There are at present 66 miles of completed railroad in Japan, and 142 miles in course of construction, with several hundred additional miles projected. These railway statistics possess of themselves great significance, but to this must be added the recent erection of several modern blast furnaces and a rolling mill under the direction of English engineers. In some of the furnaces charcoal is to be used, and in others coke. The Japanese, however, still make use of primitive processes for the manufacture of iron and steel, but this is not so much the result of conservatism or prejudice as of necessity. The ore used in these processes is largely magnetic iron sand. Other ores are to be used in the new furnaces. The annual production of iron in Japan is about 10,000 tons. Coal is mined in a primitive fashion on the island of Yesso and on other islands in the empire, the annual production being about 400,000 tons. It is mostly bituminous, but some anthracite and lignite are found. It may reasonably be presumed that the production of coal in Japan will increase in future years, as the people are disposed to adopt modern methods for its extraction. A block of bituminous coal from Japan was exhibited at Paris, as were also samples of Japanese iron ores and cutlery. In the manufacture of tools from native iron and steel Japanese mechanics are known to be both skillful and tasteful.

In *Afghanistan* and *Persia* there are small quantities of iron made by the most primitive of processes.

The grand division of the earth's surface known as *Australasia*, which includes Australia, New Zealand, Van Dieman's Land, etc., has thus far produced but little iron, but in the mining of coal much progress has been made in New South Wales, which produced 1,444,271 metric tons in 1877, of which 915,727 tons were exported. Coal mining in this colony dates from 1829. In the other colonies of Australasia very little coal is mined. Iron ore is found in New South Wales in large quantities, and furnaces and rolling mills have been erected. In the colony of Victoria there are a number of large foundries, machine shops, and rolling mills. In Van Dieman's Land a furnace was erected in 1875, and in New Zealand a furnace has also been erected. In South Australia there is another furnace. It is understood, however, that several of these enterprises have been unsuccessful. In 1877 Great Britain exported to her Australasian colonies 215,905 English tons of iron and steel. Specimens of the iron ores and coal of this part of the British Empire were exhibited at Paris, including chrome ores. In the manufacture of agricultural implements, engines and boilers, and similar products Victoria and some other colonies have made great progress. There are about 2,700 miles of railroad in Australasia.

British America contains coal at its eastern extremity in Nova Scotia and at its western extremity in Vancouver's Island, but very little coal has been developed in the intervening territory. For the manufacture of iron, however, this country could either use charcoal, of which there is abundance of timber to furnish a supply, or coal could easily be obtained from the United States. The total production of coal by the mines of Nova Scotia in 1877 was 757,496 English tons, and the production of the mines of Vancouver's Island in the same year was 154,052 tons. The exports of coal from Nova Scotia to points outside of British America amounted to 136,828 tons in 1877, principally to the United States; the exports from Vancouver's Island in the same year amounted to 139,692 tons, principally to the same country. The imports of coal into the Dominion of Canada in the fiscal year ended June 30, 1877, amounted to 979,692 tons, of which the United States furnished 789,697 tons, Great Britain 189,965 tons, and the island of St. Pierre 30 tons. Iron ore of variable quality is found at various places in the Dominion, but few of the efforts that have been made to develop it have met with success, the most successful enterprise being the works of "The Steel Company of Canada," which are located at Londonderry, in Nova Scotia, and consist of three blast furnaces, a rolling

mill, machine shops, two foundries, and an open-hearth steel plant. The company owns extensive ore and coal mines, and has a capital of $2,500,000. Its affairs are very ably managed, and every part of the works is constructed and operated upon the most approved modern principles. The whole establishment is very complete and is in constant operation, manufacturing pig iron, bar iron, car wheels, steel, etc., but it is the only complete iron-making establishment in the Dominion. The movement that has been inaugurated to give to Canada a protective tariff will do much for the iron industry of that country, and it need scarcely be added that in the prosperity of the iron and other industries of Canada this country will rejoice.

The Dominion of Canada is reported to have made about 11,000 tons of pig iron in 1877. In the same year it exported to the United States 7,755 tons of iron ore. No other statistics of production are attainable. Great Britain enjoys the lion's share of the British American import trade. In 1877 the mother country sent to British America 119,504 tons of iron and steel, which was a much less quantity than 172,079 tons which were sent in 1875. The United States exported to the Dominion of Canada, according to a statement kindly supplied by Hon. J. Johnson, the Canadian Commissioner of Customs, iron and steel and manufactures of iron and steel to the value of $5,194,909 in the fiscal year ended June 30, 1876; $4,423,336 in the fiscal year ended June 30, 1877; and $4,039,579 in the fiscal year ended June 30, 1878. The Canadian iron and steel exhibits at Paris were neither extensive nor specially noticeable. Canada has about 5,000 miles of railroad.

Mexico has iron ore in abundance, and some of her deposits are of remarkable extent and richness, but her people are not enterprising as manufacturers, nor do they have coal to stimulate them to engage in the manufacture of iron. There are less than a dozen blast furnaces and rolling mills in the country, which produce annually about 7,500 tons of iron. Mexico has about 600 miles of railroad. This country will probably not greatly increase its production of iron for many years to come.

In 1874, the latest year for which complete statistics are at hand, Mexico imported all its coal from the United States, 5,660 tons; 5,474 tons of "wrought and unwrought iron and steel" from Great Britain, and none from other countries; steam engines, machinery, and other iron manufactures to the value of $988,675, from the United States; and machinery, hardware, and cutlery to the value of $799,345, from Great Britain.

South America is not wanting in either iron ore or coal. The United States of Colombia has long had two small charcoal furnaces and a small rolling mill. Another furnace is projected. Coal is found near the city of Bogota and elsewhere. Chili produces annually about 300,000 tons of coal, but iron is not made except in very small quantities. The competition of British coal greatly interferes with the prosperity of the Chilian coal mines. In the past five years Chili has imported coal of the value of $4,000,000, of which Great Britain supplied 98 per cent. Peru has both coal and iron ore; Ecuador has iron ore; Bolivia has both iron ore and coal; and so has the Argentine Republic—all practically undeveloped. Brazil has iron ore and coal, and the government of the country encourages their development, but thus far but little has been effected in this direction. Several coal mines have been opened, and in the province of Minas Geraes some iron has been made in primitive forges.

Brazil imported in 1877 from Great Britain 340,083 tons of coal and 59,164 tons of iron and steel. Chili imported 14,218 tons of iron and steel from Great Britain in 1875, and only 1,011 tons in 1877. Peru imported 16,218 tons of iron and steel from Great Britain in 1875, and only 2,720 tons in 1877. With the exception of Brazil, no South American country consumes much iron and steel. In all South America there are about 6,000 miles of railroad.

In the fiscal year ended June 30, 1877, the United States exported to Mexico miscellaneous manufactures of iron and steel, and 438 tons of pig and rolled iron and steel, all valued at $649,588, and 1,304 tons of coal, valued at $7,746; to the West Indies and Central America, miscellaneous manufactures of iron and steel, and 3,582 tons of pig and rolled iron and steel, all valued at $1,419,893, and 80,372 tons of coal, valued at $292,979; to South America, miscellaneous manufactures of iron and steel, and 1,447 tons of pig and rolled iron and steel, all valued at $2,470,289, and 14,367 tons of coal, valued at $51,838.

SPECIAL FEATURES OF THE PARIS EXPOSITION.

In making a general survey of the features of the Paris Exposition which relate to iron and steel I am led to the conclusion that they presented but little that was new to the practical man who is engaged in the manufacture of these products. There were representations of progress in the dephosphorization of iron, in the

substitution of machine for hand puddling, in the simplification and perfection of the open-hearth process, in the casting of steel, in the manufacture of wrought iron and steel directly from the ore, and in the application of both iron and steel to new uses, but no absolutely new process for the manufacture of iron or steel was exhibited or described, nor were its products represented. The metallurgical world has apparently reached a resting place in the invention of new processes in the manufacture of iron and steel, and iron and steel makers everywhere appear to have reached the conclusion that in the improvement of present processes and in an extension of the use of iron and steel are they to find problems worthy of their attention in the future.

Of the whole display of iron and steel products at Paris, and of machinery applied to the manufacture of iron and steel or to other manufacturing purposes, I can not speak in terms of sufficient praise. The display of iron and steel products has never been equaled at a world's fair, while the display of machinery generally has only been equaled by that made at Philadelphia. The Philadelphia exhibit of machinery was more extensive and more varied than that of Paris, and it possessed an additional advantage in being more generally in motion. But the Paris Exposition demonstrated more fully than the Philadelphia Exhibition, or any previous international exhibition, the efficiency of machinery in all industrial enterprises, the efforts of every progressive nation to obtain the best machinery for its own service, and the necessity imposed upon all, by their active competition with one another, to adopt every new device and improvement which tends to increase, perfect, and cheapen products. Referring particularly to the iron and steel exhibits, and to the explanatory and supplementary information which I have presented concerning them, it is clearly demonstrated that modern processes and modern machinery for the manufacture of these products are now in general use in all leading iron and steel making countries, and that the skill necessary to apply them is rapidly being equalized. No nation now has a monopoly of the manufacture of any kind of iron or any kind of steel, or of the use of any machinery necessary to their production. Some countries will, of course, continue to display greater enterprise than others in the utilization of their resources for the manufacture of iron and steel, but none of the leading nations of the world will lag behind because they have not become practically familiar with the best methods adapted to this utilization.

Closely allied to this subject is another fact with which the observant visitor at Paris could not fail to be impressed, and which has been prominently illustrated in this report—the general distribution of good iron ores in all countries, and the equally general distribution of mineral fuel to smelt them. Countries that were once supposed to contain but little good iron ore are found to possess large and practically inexhaustible deposits of the best of ores, and countries that were not known to possess coal deposits of any magnitude or of good quality are found to possess almost boundless carboniferous resources. Sweden and Italy are the only two of the leading countries of the world that are at once rich in iron ores and poor in mineral fuel. Russia, Austria, and Germany have more and better coal than has been generally conceded to them. If Spain, Portugal, Turkey, India, China, Japan, and Australia shall ever attempt the manufacture of iron in large quantities, their progress will not be impeded because of a deficiency of domestic coal. Even in countries where native coal is not of the best quality for smelting iron ores or refining iron, the methods now generally in use for removing impurities or for making iron and steel with gas will be found to neutralize very largely this inferiority.

A fact of much significance connected with the natural distribution of iron ores was perhaps more fully illustrated at Paris than at any previous international exhibition. Owing to the marvelous increase in the production of Bessemer steel in late years the manganiferous and non-phosphoriferous ores of Spain, Algeria, and Italy have been largely drawn upon for supplies to Bessemer works in countries rich in other varieties of ores. These Bessemer ores were liberally exhibited at Paris, and they served to mark and to emphasize the great dependence of the Bessemer steel industries of Great Britain, France, Germany, and Belgium upon foreign sources of ore supply, and the virtual equalization of the cost of Bessemer ores to all these countries.

But a fact of still greater general significance was illustrated at Paris in the large and varied collection of Bessemer products which was there exhibited. All the leading iron-making countries exhibited Bessemer steel, and in almost every form in which other kinds of steel and all kinds of iron have heretofore been used. The revolution which the Bessemer process has wrought in the iron trade was made strikingly manifest in a survey of the contributions of European countries, but to an American who remembered the wonderful development of the Bessemer industry in his own country,

which sent no Bessemer products to Paris, these contributions were more impressive and more suggestive than they could be to any European. It is a trite saying that the age of steel has come, and that the manufacture of iron is giving place to that of steel, but the Paris Exposition showed that the progress made during the past two or three years in the manufacture of Bessemer steel, and open-hearth steel as well, is so great that statistics fail to give any proper conception of its magnitude. The London *Times* remarks that "the Bessemer process has ruined the manufactured iron trade;" but it has done more than this—it has distributed among many countries the manufacture of Bessemer steel, and thus enabled them to supply more fully their own metallurgical wants, and the metallurgical wants of other countries, in lieu of their own previous partial dependence upon Great Britain for both iron and steel products. It has thus aided not only to ruin the manufactured iron trade of all countries, but to ruin that of Great Britain particularly, and it has placed a limit upon the Bessemer steel industry of Great Britain itself. Here is a new revolution, or a new revelation, in connection with the world's iron industry which was reserved for Paris to make clearly manifest through the abundant proofs there furnished of the wide distribution of the Bessemer process and the wide substitution of Bessemer products for those of iron and other steel processes. And what has been said of the Bessemer process and of the injury it has inflicted upon the British iron trade is applicable also in a large degree to the Siemens-Martin process and its modifications.

With one exception, the Paris Exposition did not furnish any valuable suggestions of new uses for iron. This exception relates to the introduction of various systems of iron permanent way for railroads, in place of the wooden cross-ties and stringers which are now generally in use. One of these systems, Hilf's, has been adopted on nearly a thousand miles of railway in Germany, Austria, Belgium, and other countries. Both the stringers and the cross-ties are of wrought iron. Other systems, at least one of which substitutes steel for iron, are modifications of the Hilf system. It seems not improbable that one or two of these systems will become popular and even necessary in countries which do not possess an abundance of timber, but at present many objections are made to their adoption. It is alleged that the first cost of an iron permanent way, cheap as iron has become, is much greater than one of wood, and that it is liable to corrode, and is more rigid than wood. I did not notice at Paris nor in my travels that much progress had been

made in the substitution of iron for wood in the construction of railway cars. Concerning some other uses to which iron has been adapted within a comparatively recent period, I learned that iron is every year coming into more general use in Europe as a substitute for wood in the construction of buildings and parts of buildings, in the construction of bridges, in telegraph poles, in mining operations, and in fencing. I would not discourage the hope that the use of iron for all of the purposes which have been mentioned will increase from year to year, but this increase must be gradual in all countries, and in our own country the general introduction of an iron permanent way must be long delayed.

A product of economic interest and of rapidly increasing economic value was represented at Paris in numerous exhibits of compressed mineral fuel, or briquets, composed chiefly of inferior coal or coal waste, to which is added coal-tar as a cement. France, Belgium, Germany, and even Great Britain manufacture this new fuel, France obtaining part of her supply of the raw material from Wales, and finding a market for the sale of a portion of the manufactured product in Italy, where it is used as fuel for locomotives. Machines for the manufacture of this fuel were also exhibited at Paris, much space being occupied by them in the French section. As has already been remarked, France annually produces about 700,000 tons of briquets and Belgium about 500,000 tons; Germany and Great Britain respectively manufacture smaller quantities. Its increased production in Europe is assured. At present it is mainly used upon steamships and in locomotives. In this country a successful attempt to manufacture compressed fuel from anthracite coal dust has been made on a large scale at Fort Ewen, near Rondout, New York, and to-day the enterprise is firmly established, the fuel, which is in large lumps, being supplied to steamships and locomotives. Mr. E. F. Loiseau, an American gentleman, has recently perfected machinery for the economical manufacture of the same kind of fuel in smaller lumps, for general use. The possibilities of the compressed fuel manufacture are large and important, and do not lie wholly outside of the manufacture of iron and steel, but in this country the abundance and cheapness of good coal will long operate as an impediment to the utilization of the dust which has accumulated or may accumulate in the vicinity of our coal mines. It may be added that General Manager J. E. Wootten, of the Philadelphia and Reading Railroad Company, has invented a grate for locomotives and stationary engines by which anthracite coal dust can be

successfully and economically used as fuel. Several of these grates are in use by the company. The only American locomotive exhibited at Paris was built and sent by this company and was furnished with one of these grates, by which it can be operated with either coal dust or lump coal, without any change in the grate or fire-box. It was successfully tested on several French railroads, and has since been taken to Switzerland, where it has given great satisfaction in the use of the fuel of that country. From Switzerland it is to be taken to Italy.

During my stay in Paris it was my good fortune to be present at a meeting in that city of the Iron and Steel Institute of Great Britain. This body is composed of several hundred of the leading metallurgists of the world, a majority being iron and steel manufacturers of England, Scotland, and Wales. At its meetings, which are held at least twice a year, are discussed scientific questions of the greatest importance to all iron and steel manufacturers, and to these discussions may be justly attributed much of the progress that has been made in the manufacture of iron and steel in all countries since the establishment of the Institute in 1869. Such men as Bessemer, Samuelson, the Duke of Devonshire, Bell, Whitwell, Snelus, Mushet, Siemens, Menelaus, Adamson, Akerman, Tunner, Wedding, Gruner, Jordan, Schneider, Fritz, and Holley have placed iron and steel manufacturers everywhere under heavy obligations to them for freely giving to the world the results of their patient studies and laborious experiments in connection with the work of blast furnaces, rolling mills, and steel works. At the Paris meeting there was an unusually large attendance of the members of the Institute, and the papers read were of an instructive and valuable character. I earnestly commend to my countrymen who are engaged in the manufacture of iron and steel the example of the Iron and Steel Institute of Great Britain. All proper agencies which now exist for the acquisition and dissemination of information necessary to the continued scientific development of our iron and steel industries should be strengthened and perfected. In these industries at home as well as abroad science rules the day and the hour; old methods have passed or are rapidly passing away; and the utmost economy, skill, and technical knowledge are essential to success. Much as we have already learned—much as we have ourselves invented—I assure American manufacturers of iron and steel that we can yet learn from our fellow-craftsmen in other countries, and that we *must* learn from them if we would equal all of their best achievements.

CAUSES OF THE UNIVERSAL BUSINESS DEPRESSION.

Leaving the Paris Exposition, I now turn to a consideration of the present condition of the European iron and steel industries. First, however, it is proper that some notice should be taken of the present industrial condition of all countries which are largely devoted to manufactures.

That the manufacturing industries of leading European countries, as well as of the United States, have been depressed for many years is news to no reader of this report. This depression has had various causes, some immediate and others remote, and it has not had its beginning at the same time in all countries; but, whatever its causes, and whether early or late its beginning, it has reached all manufacturing countries, and through its influence upon them it has affected the prosperity of the whole world. Europe, being more exclusively devoted to manufactures than the United States, and having a dense population, has suffered the most from this depression; the United States, being mainly an agricultural country, with a population widely distributed, and with manufactures which have been built up for the supply of the home market rather than the foreign market, and have been protected at home from unlimited foreign competition, has suffered the least, and is the first country to begin to recover from its effects.

The inquiry is naturally suggested whether the universal depression has been created by the numerous wars of the past few years, particularly by the civil war in the United States from 1861 to 1865, the war between Prussia and Austria in 1866, the war between Germany and France in 1870 and 1871, and the war between Russia and Turkey in 1877 and 1878. Undoubtedly these wars influenced unfavorably the manufacturing industries of many countries, by first partially arresting their healthy activity and afterwards unduly stimulating their development. In the United States, Austria, and Germany this forcing of manufacturing activity was accomplished largely through the influence of an increase in the currency, itself a result of war; but neither the recent wars, nor the inflation of the currency which accompanied some of them, will sufficiently account for the depression and distress with which the civilized world is to-day so familiar.

First among additional causes may unquestionably be placed the influence of machinery in cheapening and increasing manufactured products. By means of the mechanical inventions of the past

twenty years manufacturing nations have attained a productive capacity in excess of the consumptive capacity of both civilized and half-civilized nations. This is true of manufactures of cotton, silk, and woolen goods; and it is especially true of manufactures of iron and steel, in which must be included all railway appliances. This development of manufacturing facilities would have taken place if there had been no wars, for the invention of the steam engine, of railroads, and of the magnetic telegraph, and the discovery of gold in California and Australia gave such an impetus to the world's progress that improvements in labor-saving machinery, for the supply of new wants and to meet new conditions of civilization, were certain to follow.

Next among the causes of world-wide depression must be placed the slackening of the demand for new railroads. For a period of about ten years prior to 1873 all of the leading countries of the world and many of the second and third rate countries were actively engaged in building railroads, to afford means of communication between the several parts of their territories or to develop their latent resources. Many countries which were rich in enterprise but poor in ready money were assisted by the money-lenders of other countries to build these roads. While this work was in progress many branches of manufactures and of mechanical and engineering construction were liberally drawn upon for materials and labor, and to meet this demand the erection and equipment of new iron and steel works, locomotive works, car works, and minor industrial establishments were rendered necessary. In 1873 and immediately succeeding years it was found that as many of these railroads had been constructed as were required by the necessities of the countries building them, or as they were able to pay for, or could borrow money to pay for, and with the total or partial cessation of the demand for new railroads a check was at once given to all the industries which had been built up or enlarged in expectation of a continuance of this demand. Millions of capital were found to have been unprofitably invested; armies of skilled and unskilled workingmen were thrown out of employment; and small industries, dependent upon the prosperity of the greater industries which had been abnormally stimulated, either perished outright or were able to maintain only a sickly existence.

The railway statistics of Great Britain, Germany, and the United States are sufficiently illustrative of the stimulating influence upon the iron trade and related industries of the fever for building new

railroads that has existed in late years, and of the depressing effect of the subsidence of this fever. From 1855 to 1873 the railway mileage of Great Britain increased from 8,335 miles to 16,082 miles, or almost doubled. At the beginning of 1878 the mileage had increased to only 17,109 miles. The railway mileage of Germany increased from 4,863 miles in 1855 to 8,637 miles in 1865; to 17,372 miles in 1876; and to 18,828 miles at the beginning of 1878. The decline in 1876 and 1877 was continued in 1878. The railway mileage of the United States increased from 18,374 miles in 1855 to 35,085 miles in 1865, almost doubling, the civil war preventing a greater increase; but in 1873 the large mileage of 1865 was fully doubled, the number of miles then in operation being 70,311. In one year alone, 1871, no less than 7,608 miles were constructed. But from 1873 to 1877 only 8,897 miles were constructed, an average of a little more than 2,200 miles in four years. The average for the eight years from 1865 to 1873 was over 4,400 miles annually. The mileage for 1878 was about 2,600 miles.

To show how rapidly the iron industry alone was developed in the years immediately preceding the beginning of the present depression I give the statistics of the world's production of pig iron in each of the years 1855, 1872, and 1873, as follows: 1855, 6,889,906 English tons; 1872, 14,470,358 tons; 1873, 14,706,459 tons. The production of 1855 it is seen was more than doubled in 1872, a period of only seventeen years. This progress could not be expected to continue, and accordingly we find that in 1873 the production was only slightly in excess of that of 1872. In 1873 production reached its maximum, and since then it has steadily declined, the figures given in the beginning of this report showing a present annual production of only 13,807,725 tons. Stated more emphatically, the annual production of pig iron which more than doubled between 1855 and 1872 has declined almost a million tons from 1873 to 1878.

While the fever for building railroads was everywhere at its height another influence was actively at work to assist in destroying the prosperity of the iron industry by destroying to a large extent the demand for iron itself. A revolution involving the general substitution of steel for iron had been commenced, and so popular did it become that all the leading countries were soon engaged in promoting it. The Bessemer process and the open-hearth process for converting iron into steel at first helped only to meet a universal demand for both iron and steel, but when the merits of these processes became fully known, and works devoted to them were established

in many places, they gradually wrought a diminution in the hunger for iron, especially iron rails, and contributed greatly to precipitate the depression in the iron industry, and in all industries more or less dependent upon it. The new processes not only rendered useless hundreds of iron establishments which had been called into existence by the wants of new railroads and the exigencies of war, but they gave to the world products of greater durability than iron at approximately the same cost, thus decreasing the demand for iron ore, coal, and other raw materials which are common to the manufacture of both iron and steel. They did more than this: they almost wholly destroyed the large demand that had existed for years for finished iron and for heavy iron machinery for the construction of blast furnaces and iron rolling mills.

We have here four leading causes of the world-wide business depression of the past few years: destructive wars; the general substitution during the past twenty years of labor-saving machinery and of more rapid processes of manufacture; the culmination of the fever for building new railroads; and, lastly, the partial destruction of the world's iron industry by the revolution created by the introduction of the Bessemer and open-hearth processes. These causes of depression have operated with almost equal force in countries engaged in war and in countries which were not so engaged; in countries which had an inflated currency and in countries which did not have it; in countries largely engaged in manufactures and in countries only slightly engaged in them. But, of all the countries visited by the hard times of the past few years, those least injuriously affected and possessing to-day the brightest prospects for an industrial future are the two which have most protected their home industries, the two great republics, France and the United States.

I now reach the proposed inquiry into the present condition of the iron and steel industries of Europe.

PRESENT CONDITION OF THE EUROPEAN IRON TRADE.

After the Austrian panic of 1873 the building of railroads in the Austrian Empire received a severe check, the production of pig iron and iron rails materially declined, and the imports of all iron and steel also greatly declined. The Bessemer steel industry of Austria has been very slowly developed, but its development has almost sufficed to destroy the Austrian iron rail trade. In 1878 the country

had not recovered from the depression which began in 1873, but it was adhering, and has since determined to adhere, to its protective tariff, through which its iron and steel manufacturers are supplying the limited demand that exists for their products, and its other manufacturers are secured the virtual possession of the home market.

The results of the business depression have been far more disastrous in Germany than in Austria. For about two years after the close in 1871 of her war with France, Germany was prosperous. Labor was in demand, and wages and prices advanced. But in 1873 symptoms of a decided reaction were manifested, and in that year the prosperity of the German iron and steel industries culminated, and it has since continued steadily to decline. This reaction would not have been so severe as it has been if the German Government, in an excess of generosity which is unaccountable, had not at the beginning of 1877 removed all duties on foreign iron and steel, thus increasing the severity of foreign competition at a time when domestic manufacturers of iron and steel were struggling with other causes of trade depression. A German statistical authority last year summarized as follows some of the consequences to the German iron trade of the reaction which commenced in 1873.

Between 1872 and 1876 the number of iron mines in operation in Germany, including the Grand Duchy of Luxemburg, declined from 1,341 to 1,026, and the number of miners from 39,421 to 28,138. Within the same period the number of furnaces in blast fell from 348 to 297, and the workmen employed from 26,111 to 20,500. Between April, 1873, and April, 1877, the number of workmen employed by 22 of the principal companies engaged in the iron trade (excluding Krupp) fell from 27,700 to 14,600. Within the same period the value of the stock of the Phœnix Company fell from 16,200,000 marks to 4,860,000 marks; of the Hörde Company from 15,000,000 marks to 3,210,000 marks; of the Bochum Company from 15,000,000 marks to 3,375,000 marks; of the Dortmund Union Company from 41,400,000 marks to 2,070,000 marks; and of the Donnersmarkhütte Company from 18,000,000 marks to 3,906,000 marks. Of 32 companies, whose united capital amounted to £15,600,000, only six showed any dividend whatever for the year 1876, and the aggregate accounts published for that period showed a balance of loss on the year's operations of £359,000 on that capital, as compared with a loss of £195,000 for the previous year.

A consular report to the United States Government in May, 1878, stated that in Westphalia at that time all manufacturers were "living on their capital, working away with yearly losses, waiting for the arrival of better times." Another consular report

from Brandenburg, written about the same time, stated that "the returns of the great railway companies for the first quarter of the year show again diminished receipts, both for goods and passengers, and the stockholders in some cases will receive no semi-annual dividend." A German newspaper of recent date contains the following statement: "The Borsig Locomotive and Machinery Works, one of the proudest monuments of the iron trade of Germany, are, it is reported, about to be closed for an indefinite period. For some time past they have had to be kept going out of savings, and this the trustee of the Borsig estate declines to continue to do any longer. The works have been conducted at a loss for so many years in succession that they threaten to swallow up the entire estate." It need scarcely be added that both wages and the prices of manufactured products have greatly fallen in Germany since 1873. In the beginning of that year, it is stated, a passenger locomotive would bring £3,420, and is now worth only £2,225; first-class passenger cars have fallen from £750 to £450; second-class, from £712 to £420; third-class, from £402 to £260; fourth-class, from £309 to £220. While in 1873 German manufacturers were called on to supply 332 locomotives, 924 passenger cars, and 4,006 freight cars, the orders in 1878 embraced only 68 locomotives, 336 passenger cars, and 1,901 freight cars. The depression in all manufacturing industries was supposed to be at its height in 1878. Many workmen were unemployed, and the general distress was very great, but this the government was endeavoring to alleviate.

The wonderful recuperative power which France displayed after the close of the war with Germany was illustrated in the revival of her iron and steel industries, but of late much difficulty has been experienced in maintaining the steel as well as iron establishments of France in operation, and but for the strongly protective policy of the country, which has many forms, the difficulty would have been much increased, and financial and social distress would have been general. But France not only maintains high duties on foreign manufactures: she still further protects her home manufactures by doing her utmost to furnish them with employment. The building of railroads, for instance, has been greatly promoted by the government, and in the supply of rails and other material for new and already constructed railroads it is insisted that home products shall be preferred. The close relations which the government sustains toward the railroads makes it possible to have its wishes respected. Notwithstanding the help of the government,

however, many iron and steel works of France, chiefly iron rail mills and blast furnaces, were not employed in 1878. Prices have fallen to a very low standard, Bessemer steel rails having recently been reduced from $40 to $35 a ton, and ordinary bars at Paris to 147½ francs, or $28.47 a ton. The wages of labor are also very low. A French journal which is recognized as an authority stated at the beginning of 1878 that "production is beyond consumption; production has been too rapid, and must wait until an equilibrium has been established." It is worthy of note that the French iron and steel and other industries were not stimulated into activity by an inflated currency, as was partly the case in Austria and Germany, but that they have reached the point of development stated by the French journalist in defiance of a positive contraction of the currency, resulting from the payment of the heavy indemnity to Germany.

French iron and steel makers have had great natural disadvantages to contend with. Although there is no scarcity of native ore and coal, their quality is not usually the best that could be desired. The coal is generally very impure and requires to be washed before it is coked; the ore is not well adapted to the manufacture of steel. Large quantities of both coal and ore are imported for use in French iron and steel works, and owing to inland transportation their original cost is greatly enhanced. It is only in consequence of low wages and long hours and by the practice of the utmost economy in all details that France is enabled to manufacture iron and steel at prices approximating those which prevail in neighboring countries.

The Belgian iron and steel industries were not so generally depressed in 1878 and immediately preceding years as those of Austria or Germany or Great Britain, the degree of depression they experienced corresponding more nearly to that of the French iron and steel industries. With a great effort, and with the help of orders from the Belgian Government itself, nearly all of the iron and steel works of the kingdom, with the exception of blast furnaces, were kept in operation, although many were not operated to their full capacity. It has been partly through frequent reductions in wages that the Belgian ironmasters have kept their works in fair activity, and have been enabled, as has been officially stated by the secretary to the British Legation at Brussels, "to buy pig iron in England, pay for freight, and deliver the same iron manufactured into beams and girders in the most central parts of England, or

even in the heart of the iron districts, at a lower price than it can be made by English firms on the spot." Belgium will continue to be a formidable competitor with other countries in supplying the iron and steel markets of the world.

The iron and steel industries of Russia have not suffered from over-production, as they have not in late years fully supplied the home market. The recent purchase in the United States by Russia of four iron steamships and forty locomotives indicates this truth very plainly, if other statistics of Russian imports did not. Russian iron and steel manufacturers have had much to contend with in the poverty of the people, in the unsettled political condition of Russia, in the lack of sufficient means of communication, in the small consumption of iron and steel except for railway and military purposes, and in the want of skilled workmen, especially for the development of the coal deposits of the country. The inducements to embark in the manufacture of iron and steel are not such as usually exist in other civilized countries. Russia is not conspicuously a manufacturing country, although she has certainly made rapid advances in late years in supplying her own wants. Her export trade in manufactured products is very small, and her imports are large. I do not look for Russia to recover rapidly from the effects of her war with Turkey, but she may be expected to strive hard to supply her own wants for iron, steel, and other manufactured products, and to exhibit a constantly diminishing demand for like products of foreign manufacture.

There have of late been many financial failures in the ranks of Swedish iron and steel manufacturers, and many works have been closed. Production has been practically stationary for years, although the number of modern iron and steel works has in the meantime been increased, especially Bessemer steel works. But other countries can make Bessemer steel cheaper than Sweden, and but little of this product that she makes is exported, and she makes but little. With the increased use of Bessemer and open-hearth steel in other countries the demand for Swedish iron has declined, even for her best brands for conversion into crucible steel. Swedish iron and steel makers are thus placed between two fires; they are deprived of a portion of the home market through the absence of protective duties, and they can not make either iron or steel at prices sufficiently low to enable them to become formidable competitors with other makers in foreign markets. I can see but little prospect for an improvement in the Swedish iron and steel indus-

tries, and none whatever so long as the Swedish tariff remains as it is.

The Italian and Spanish iron and steel industries are not of sufficient importance to call for further remark concerning their present condition than to state that, small as they are, they are not equal to the supply of the home demand for iron and steel. Other countries, however, will probably not be called upon to supply large quantities of these products to these countries in the near future, for neither country is prosperous, both having suffered greatly from political troubles and from the want of that industrial enterprise which characterizes the northern countries of Europe. In supplying iron ore to more enterprising nations both Italy and Spain will be likely to become more prominent from year to year. Norway, Switzerland, Portugal, and Turkey will not make much iron or steel, nor will they need much from any source.

The tide in the prosperity of the British iron and steel industries has ebbed with the refusal or inability of other countries to buy British iron and steel in the large quantities that were a few years ago required. The exports of these products have steadily declined from 3,382,762 tons in 1872 to 2,299,223 tons in 1878, and their value has declined from £37,731,239 in 1873, when the highest prices were obtained, to £18,393,974 in 1878. In 1870 the exports of British rails and rail fastenings amounted to 1,059,392 tons; in 1878 they amounted to 441,384 tons. During the years intervening between 1872 and 1878 Great Britain greatly expanded her Bessemer steel trade, and the decline in the aggregate quantity and value of her iron and steel exports is therefore all the more significant. As a result of this decline, many of her blast furnaces and rolling mills have been closed, and not a few of their owners have been bankrupted. The iron rail trade of Wales and Cleveland has been pronounced by British writers to be "dead." Of 6,662 puddling furnaces from which returns had been obtained at the close of 1878 there were only 3,616 in operation. Of 977 blast furnaces existing at the close of the same year there were only 459 in blast. The production of pig iron in Great Britain attained its maximum in 1872, when 6,741,929 tons were made; in 1878 the production fell to about 6,300,000 tons, and the stocks of pig iron on hand at the close of the year amounted to 679,000 tons in Scotland, and to 337,337 tons in Cleveland. In 1873 the Cleveland district manufactured 324,420 tons of iron rails; in 1878 only 21,000 tons were manufactured. The price of Scotch pig iron fell

from 145s. in 1873 to 42s. 3d. in 1878, which was the lowest price reached during the past twenty-six years. It was stated at the close of the year that "undoubtedly the year 1878 was the most gloomy and unsatisfactory ever experienced by the iron trade of Scotland." The price of good forge pig iron in Cleveland had fallen to 34s. 6d., or $8.40, in December, 1878. Alluding to this price, an English technical journal has remarked that "it does not require a very powerful intellect to establish the stern pitiless fact that at such a price the manufacture of pig is carried on at an infinitesimal profit—if, indeed, at any profit at all." The price of best Staffordshire bar iron fell from £16 15s. in 1873 to £7 10s. in September, 1878. The struggle for existence is so severe in the British iron trade that the Cleveland ironmasters have made serious inroads upon the pig iron trade of Scotland, having supplied Scotch consumers with 303,176 tons in 1878, and it is announced that they "are prepared to make further sacrifices to keep up the deliveries into Scotland."

The London *Times*, in its issue for January 3, 1879, forcibly presented in the following summary the rapid development of the iron and steel industries of Great Britain during the past few years, and their present condition.

The aggregate output of Bessemer steel in the United Kingdom during 1878 has not been short of 850,000 tons, while of open-hearth or Siemens steel the production has been at least 150,000 tons more, making a total output, in round figures, of about 1,000,000 tons of steel; whereas in 1870 the production of both was under 230,000 tons. During 1878 new steel works have been put into operation at Rhymney and other places, and considerable additions are now being made to existing works in different parts of the country. As Bessemer steel works increase and multiply, so must finished iron works diminish in value and in number; and it is of considerable moment that this should be better understood than it is at the present time. The finished iron trade of this country came to the front with extraordinarily large and rapid strides. In 1860 there were only 208 works for the manufacture of finished iron in the United Kingdom. In 1864 this number was increased to 248; in 1872, to 276; in 1874, to 298; and in 1877, to 312. The number of puddling furnaces employed in these works increased from 3,462 in 1860 to 6,338 in 1864, and 7,311 in 1872; but in the years 1874 and 1877 the number showed a slight decrease, owing to the growing depression of trade. Of rolling mills at work in the United Kingdom, the number increased from 439 in 1861 to 866 in 1871, and 942 in 1876. This development was, of course, induced by the demand for rails and plates made upon us by other countries up to the close of the year 1873, when our former customers began more generally not only to supply themselves but to become our rivals in neutral markets. Within 15

years the resources of production in the manufactured iron trade of the United Kingdom increased to the extent of 2,467,000 tons, an increase far in excess of any probable demands. Of the 104 new finished iron works erected between 1860 and 1877 many have now been closed for three or four years, and others are falling into this category almost every day. In the North of England fully a million and a half sterling invested in finished iron works has been yielding no return for upwards of three years; and in Wales probably a larger capital has been altogether unproductive. In both districts many works are valuable only for the old bricks and scrap iron to be obtained by their demolition.

The production of pig iron in Great Britain has been maintained at almost the standard of 1872 because of the very low prices at which it has been possible to manufacture it, thus permitting its exportation in large quantities to Germany, Belgium, and other countries. The decline in the British iron and steel exports has been in manufactured iron. To send abroad raw or half manufactured iron products, with a constantly declining demand for finished iron products, is a condition of the British iron trade which brings the least pecuniary profit with the least employment of skilled labor but with the largest consumption of native wealth.

Nor is the Bessemer steel manufacture of Great Britain prosperous. It is suffering to-day from over-production. In destroying the British iron rail trade it is not clear that it has not commenced to prey upon itself. Bessemer steel rails are now sold at the same prices as good iron rails, a Sheffield firm having recently accepted an order for 25,000 tons of steel rails for the Northeastern Railway Company at £4 9s. 6d., or $21.78. Competition between the owners of Bessemer establishments in Great Britain is so severe that already many of these establishments have been virtually closed. I have just read in an English journal that "it is a fact that there are works which have not rolled a single rail since Christmas." One result is certain to follow the severe struggle that is now in progress in Great Britain: not only iron rails but also all forms of manufactured iron and even crucible steel of British manufacture must be driven more and more from British and foreign markets.

The extraordinary development of the British iron and steel industries which has been noted has been almost equaled by the rapidity with which other British industries have been developed since the close of our civil war. These other industries, too, have suffered from the effects of over-production as severely as the iron and steel industries. During 1878 the total number of business failures in

Great Britain was 15,059, an increase of 4,037 in comparison with 1877. In the undue development of British manufacturing industries and in the subsequent misfortunes which have overtaken them an inflated currency has had no part, and until recently a protective tariff has had no friends.

THE PRESENT CONDITION OF LABOR IN EUROPEAN COUNTRIES.

Inseparably connected with the condition of the iron and steel and other manufacturing industries of Europe is the condition of European labor. In proportion as these industries have been depressed so has labor lost its opportunities or gone without sufficient reward. The working population of Europe which is employed today is in receipt of wages which compel the severest economy in personal and household expenses, and which are, with few exceptions, lower than the wages paid to them before the late era of industrial activity and speculation. The number of the unemployed, and of those who earn a precarious subsistence in employments to which they are unaccustomed, is in most European countries larger than has been known for many years, and is especially large in Germany and Great Britain. But for the maintenance on the Continent of large standing armies, which withdraw many thousands of skilled and unskilled workingmen from competition with their fellows, the number there would be so great as to endanger the public peace. A few illustrations will suffice to show the present condition of European labor in both manufacturing and agricultural districts, but particularly in the former.

In France, in May, 1878, the average daily wages of carpenters were $1; of masons, 75 cents; of painters, 95 cents; of shoemakers, 60 cents; of tailors, 75 cents; of women employed in various mechanical occupations, from 35 to 60 cents; and of children similarly employed, from 10 to 35 cents. At Creusot, where the highest wages on the Continent are paid to ironworkers, the net wages of puddlers in 1878 were about $2 a day, and helpers received about 75 cents. At the blast furnaces at Saint Chamond in 1878 an ash wheeler received 50 cents a day, an ordinary laborer 65 cents, a fireman 70 cents, and engineers 70 to 90 cents. The average annual earnings of French colliers in 1872 were only 980 francs, or $189.14, and their earnings are now still less. In 1877 the French Mining Department gave the average wages earned by the men employed in all the coal pits and iron mines in France as

being from about 1s. 9d. to 2s. 4d., or 43 to 57 cents, per day of about 11 hours. In the same year Mr. Frederick Brittain, an English commissioner to inquire into the rates of wages then paid in France, reported that at an iron works visited by him he found the wages of the preceding six months to have averaged 3s. 6½d., or 86 cents, per man per day of 11 hours; at several other iron works he found that the wages ranged from 2s. 6d. to 4s. per day of 11 hours. In the machine shops at Lille he found that the wages paid were 2s. 2½d., or 54 cents, per day for laborers, and 3s. 4d. to 3s. 9d. per day for mechanics, the day being 11 hours long. Since 1877 wages have been reduced in France, but they are still higher than are paid in most Continental countries. A recent consular report to our own government places the average daily wages in France at 45 cents, and the amount of the annual revenue of a representative French family, composed of father, mother, and five children, one of which is old enough to work, at $179.20. Its average annual expense is estimated at $167, or $3.21 a week.

During the first half of 1878 the average daily wages of colliers in Belgium were 2.86 francs, or 55 cents, per day, which was a decline from 3.08 francs a year previously. The average wages of skilled labor in Belgian iron works had increased in 1872 to 11 francs per day of 11 hours, but in 1876 they had fallen to 5 francs, and in 1877 to 4 francs, and even to 3½ francs. The steam hammer man receives 4 francs per day, and the puddler who pays his own help receives about $2 per ton of puddled bars. The secretary of the British Legation at Brussels reports that "a Belgian laborer works from Monday morning at six o'clock until Saturday night at twelve without intermission, and lives on food on which a British laborer would starve."

In Russia the wages of a peasant usually range from 14 to 37 cents a day, and the wages of his wife or daughter from 7 to 14 cents. At Odessa the price of labor has reached the extraordinary height of 50 cents a day. Throughout Russia the average rate of peasants' wages is 25 cents a day for men, 12½ cents for women, and 37½ cents for a man and his horse and wagon. The products of the farm bring proportionate prices: a sheep 25 cents; a cow $3 to $4; and a horse $5. The luxuries of civilization are almost unknown to the peasants and working classes of Russia.

The wages of skilled workingmen in Austria have been reduced about 20 per cent. during the last four years. The silk industry furnishes employment to many Austrian men and women. In

1871, when Austria was prosperous, first-class cocoon winders received $1.80 per week of 72 hours, and raw silk winders received $1 per week of 60 hours. The Austrian State Railways employ over 12,000 men, women, and children. The wages of the men vary from 36 cents to $1.09 a day; the average wages paid to the women are 20 cents a day, and to children 16 cents a day.

In Westphalia, in Germany, the wages of general workmen in iron and sheet ware works in 1875 were $4.50 a week, and the wages of day laborers were $3.80 a week; in iron foundries moulders received $4.64 a week and day laborers $3.90 a week, the week being composed of six days of 11 hours each. Agricultural laborers throughout Germany received from 31 cents to 53 cents daily in 1878 if men, and if women about one-third less. Men laborers in towns received from 50 to 55 cents a day; women from 25 to 37½ cents; workmen employed on public works from 40 to 57 cents. In the Thuringian States carpenters, blacksmiths, masons, and bricklayers received from 55 to 62½ cents; tailors from 45 to 50 cents; railway brakemen from 40 to 45 cents, with an additional allowance of about $5 a month for mileage. In all the cases mentioned boarding is not included. In Brunswick, Germany, skilled workmen received from 48 to 76 cents a day, without board. At Bremen wages per week were as follows: shoemakers, $2.50 to $3.75; carpenters, $3.75 to $5; tailors, $5 to $6.25; masons, $3.75 to $5; blacksmiths, $2.50 to $3; joiners, $2.50 to $3. The present rates of wages in Germany are from 15 to 20 per cent. lower than in 1876. As an illustration of the distress which prevails, the official statement has been made that the burgomaster at Coburg employed 200 laborers during the winter and spring of 1878 in laying out and grading an addition to the city cemetery, and paid each man 26 cents as daily wages upon which to keep body and soul together.

In Italy the average wages of masons, carpenters, smiths, and other mechanics are about 65 cents per day of 12 hours, the minimum being 50 cents and the maximum $1.20. Ordinary laborers on government railways are paid from 50 to 60 cents a day; conductors, engineers, and other railway employees are paid liberal wages. Silk spinners (women) are paid from 18 to 24 cents per day of 13 hours, including lodging but not board. Agricultural laborers throughout Italy receive from 25 to 40 cents a day, without board, except in harvest, when they are paid from 60 to 70 cents per day of 15 hours.

In Great Britain the wages of labor have been repeatedly reduced

during the past few years, and every week brings us telegraphic intelligence of still further reductions. One of the latest dispatches by cable states that "the reduction of 12½ per centum in the wages of which the Fife and Clackmannan colliers have received notice will make their average wages three shillings a day, which is lower than for many years; but no serious opposition to the reduction is anticipated." In October, 1878, the earnings of Scotch miners averaged 2s. 9d. a day.

The wages of British colliers, iron miners, and iron workers are lower now than they were before the recent rise in prices. The wages of Northumbrian coal miners are 15 per cent. below the level from which they had advanced, and a further reduction is impending. In Durham the price now paid per ton for mining coal is 1s. 10d., and in 1871, before the rise, the price was 2s. a ton. Notwithstanding this reduction, notice of a still further reduction of 20 per cent. has been given to the Durham miners, and the surface laborers at the mines have been notified that a reduction of 12½ per cent. will be made in their wages, coupled, however, with a reservation that the wages of able-bodied men shall not be brought below 2s. 6d., or 61 cents, a day. In the iron-mining industry in the North of England, wages which in 1871 were fixed at the rate of 11d. per ton rose to 1s. 4d. per ton in 1873, and have now fallen to 10d., from which it is probable that a penny per ton will shortly be taken. As far back as the summer of 1877 it was announced that the South Staffordshire coal trade was so depressed that but little more than half time was being made at the collieries, and that the earnings of the colliers did not average more than from 12s. to 14s. a week. The situation is worse to-day. The price of puddling in England is now 7s. 6d., or $1.82, a ton, and about one-third of this sum the puddler pays to the helper. In 1873 the price of puddling was 13s. 3d. a ton; the reduction to 7s. 6d. is therefore almost 44 per cent. In the United States the price of puddling, if I am correctly informed, is nowhere to-day lower than the highest English price in 1873, and at Pittsburgh it is $5 a ton, or almost three times the present English price. Other branches of British industry than the coal and iron trades have experienced a depression so severe that the wages of workingmen employed in them have also been frequently and greatly reduced, but I refrain from giving details. In their efforts to force down wages the masters have been strenuously resisted by their workmen, but the former have been successful in every contest. During 1878 there were

no fewer than 277 strikes in Great Britain; in 1877 there were 181.

Much destitution and suffering have prevailed among British workingmen and their families in consequence of the reductions in wages which have been noted, but the full force of the existing hard times in Great Britain has fallen upon the tens of thousands who have been thrown out of all employment and denied any wages. Upon this sad story I do not propose to enter further than to show that no relief has yet been found for the unemployed, and that the struggle for life itself is now very severe. Two recent cable dispatches show how great is the existing distress in one of the leading iron and steel manufacturing districts of England.

LONDON, Nov. 20, 1878.—A state of appalling distress and destitution exists among the mechanics and laborers of Sheffield, in consequence of the business depression. Hundreds of persons are living in tenements without clothing or furniture, which they have been forced to sell to procure food. They are without fuel and are dependent upon the charity of their neighbors for subsistence. The mayor has called a public meeting to devise measures of relief.

LONDON, Feb. 28, 1879.—The mayor of Sheffield stated at a meeting yesterday that in one district of that town there are 4,000 persons destitute, and 400 families are actually starving. The relief fund, except about £800, has been expended.

It is announced that, at Chester, in February last, the guardians, in order to provide work for the distressed laborers, had given employment in stone-breaking, at 1s. 6d. a day, to as many as desired to apply for it at the workhouse. Relief committees and soup-houses are to-day found in most mining and manufacturing districts in England, Scotland, and Wales. The trades unions are assisting their unemployed members to emigrate to the United States and other countries, and English newspapers urge all the unemployed to emigrate if they can find the necessary means. It is mentioned, however, that "wholesale emigration has but partially mitigated the distress in the Cornish tin-mining industry, thousands of penniless women and children being left behind. Hundreds of men unable to emigrate are absolutely without employment. The distress has now exceeded the bounds of private liberality." The distress in England is said to be more general and pitiful than that which accompanied the "cotton famine" in 1862.

In all European countries women are engaged in many masculine employments, and children in employments to which they are unsuited. Of 5,887 persons employed in the iron mines of Sweden

in 1876, there were 421 women and girls. At Creusot and other French iron works women perform a large part of the labor about blast furnaces and above ground at the coal mines. All the work at the coal washers is done by them, and they are also employed in wheeling coal. French women work in the fields, performing the labor of men, and in some of the cities of France they may be seen cleaning the streets, digging cellars, and doing other work which in our country is only performed by men. Women and children, both boys and girls, work about Belgian blast furnaces, wheeling coal and ore, and also work in the coal mines. The government recently refused to exclude women and girls from the mines, but fixed the minimum age of boys working in the mines at 12 and that of girls at 13 years. In Italy, Austria, and Germany women work as regularly in the fields as do the men. In Wales they engage in many laborious out-door employments. In England thousands of young girls are still employed in carrying clay in the brick-yards. The poverty of the working people of Europe, especially since the reaction in prices and wages a few years ago, is doubtless the principal reason why women and children help to do the work of men, the earnings of all the members of the family who can work being necessary to keep the wolf from the door. It will readily be inferred that the food, and clothing, and household comforts of the family of a European workingman are not such as the families of our well-to-do American mechanics and farmers are accustomed to. A condition of society which requires such sacrifices and imposes such privations is not desirable in this country.

AMERICAN COMPETITION IN FOREIGN IRON AND STEEL MARKETS.

A study of the present condition of the iron and steel industries of Europe and of the condition of European labor naturally leads to the inquiry whether the iron and steel manufacturers of the United States can compete in foreign markets with industries so depressed and with labor so poorly rewarded, and to the further inquiry whether they could hold possession of the home market if the protection now afforded by duties on imports were withdrawn. It is clear to me that if the crude and coarse forms of iron and steel be considered, such as pig iron, bars, rails, plates, sheets, and beams, neither of these inquiries can be answered in the affirmative.

It is well known to every well-informed person that the prices of iron and steel in this country never were so low as they are to-day,

and that these low prices are the result of the severest home competition which has ever been experienced. In the struggle for the possession of the home market which the financial panic of 1873 precipitated and entailed upon our iron and steel manufacturers they have made use of every resource that science, and skill, and economy could suggest as a cheapening influence. Improvements in machinery and in processes have been made at great expense; old methods of manufacture have been modified or discarded; search has been made for better and cheaper raw materials; wages and profits have been reduced. Many manufacturers have resorted to all the expedients here named, by which they hoped to keep their establishments in operation, and yet have been unable to maintain their hold on the market, and with the failure to do this have retired from business or been forced into bankruptcy. With the knowledge of this severe competition and its effects before us it is not a reasonable supposition that prices can go much, if any, lower than they now are. And yet there are many countries in Europe in which both iron and steel are made much more cheaply than in the United States. Competition in these countries has been as severe as in this country; bankruptcy has followed bankruptcy; wages, always lower than in the United States, have been reduced and reduced again. Special natural advantages, joined to low wages, have combined with a slackening demand to bring the prices of iron and steel in Europe down to a level which has never before been reached.

Among the natural manufacturing advantages referred to cheap transportation is most prominent. In the United States our best ores are found at long distances from the fuel that is needed to smelt them; much of the pig iron manufactured is necessarily made at long distances from the works which refine it into finished iron and steel; and even the finished product is usually transported hundreds of miles before it reaches the consumer. In Europe the ores and fuel are usually found in proximity to each other and to finished iron and steel works, or can be cheaply transported. The territorial extent of the leading manufacturing countries of Europe is small indeed when compared with the wide extent of our own country, and the mineralogical riches of Europe are distributed with remarkable evenness. Hence railroad transportation is not there the tax that it is in this country, and canal and ocean transportation still more cheaply serve the European manufacturer by bringing to him raw materials or taking his finished product to a

market. Great Britain alone has over 4,000 miles of canal, and her facilities for receiving and shipping raw materials and manufactured products by sea are unequaled.

My distinguished friend, Mr. I. Lowthian Bell, M. P., in his report to his government on the iron and steel resources of the United States, as represented at the Philadelphia Exhibition, saw and recognized the influence of long lines of transportation in adding to the cost of American iron and steel products. He said:

> The vast extent of the territory of the United States renders that possible which in Great Britain is physically impossible; thus it may and it does happen that in the former distances of nearly 1,000 miles may intervene between the ore and the coal, whereas with ourselves it is difficult to find a situation in which the two are separated by even 100 miles.

This is a frank statement of facts, but I may add to it another important fact, which the books of leading manufacturing companies will verify, that fully one-third of the cost of all the finished iron and steel that are made in the United States is created by unavoidable railroad transportation. If it were possible to make iron and steel in this country without paying this tax to the railroads, there are few railroads that would pay a dividend to their stockholders, and the building of new railroads would practically cease, for all our leading railroad companies derive a large part of their revenue from the transportation of the ore, coal, coke, limestone, pig iron, and finished iron and steel used at or produced by our iron and steel works. With the cost of transportation reduced fifty per cent., and the price of labor reduced to the European standard, this country could make iron and steel as cheaply as Europe, but neither result is possible, and neither is desirable. It is not wise statesmanship, nor true economy, nor humanity worthy of the name that seeks to cheapen any product by making capital a coward and labor a slave. But labor in this country can not be made the slave that it is in Europe, if legislation would seek to force such a result. Its greater intelligence, its political privileges, and its wider opportunities forbid the degradation. It would speedily reverse at the ballot-box all hostile legislation, and millions of fertile and unbroken acres in the West will long afford an outlet to surplus labor in our manufacturing districts.

We will doubtless continue to increase our exports of such products as hardware, edge tools, and light specialties, in the production of which American ingenuity has given us an advantage;

but bulky iron and steel products, which are manufactured with materials and by the employment of skill that Europe possesses in common with ourselves, we can not export in appreciable quantities, even to our nearest neighbors. A reference to the statistics of American exports will show that we can not. Our iron and steel manufacturers will do well to abandon the hope that such a result is possible. The statesmen of the country need not look for these manufacturers to swell our foreign commerce with their products. The home market is all that they can supply under existing conditions, and in supplying it with good iron and good steel at the lowest prices ever charged to American consumers they will find sufficient employment for all their energies and perform a service to their countrymen far greater than could follow an uncertain struggle with overcrowded countries for the supply of foreign markets.

I trust that no man, be he statesman or manufacturer, will be deluded with the thought that our most formidable manufacturing rival, Great Britain, will cease her efforts to regain possession of our home markets. Her manufacturers of cotton, woolen, iron, steel, and other products are forcing labor to accept as low wages as are paid in the poorest country on the Continent of Europe, and with the many natural and acquired manufacturing advantages which they possess they will in a little while set at defiance the manufacturing advantages of all other countries. Temporarily under a cloud, because of the progress made by other countries in developing their own resources, or because of their financial inability to continue the large orders once given to her manufacturers, Great Britain will make a desperate effort to emerge from it by seeking to undersell the whole world. Against this fresh assault most Continental countries, and some British colonies, will defend themselves with protective tariffs, and if this country would not see many of its leading industries overthrown it must resolutely adhere to the revenue policy which has developed those industries and which is enabling the country to-day to enter with hope and confidence upon a new era of prosperity. I would not excite unnecessary fears, but my duty to my countrymen would not be performed if I did not warn them of the danger which will constantly impend over their industrial welfare so long as a powerful rival is able to force its labor to the lowest point of human endurance, and untiringly seeks by diplomatic and other methods to force the products of that labor upon countries which do not want them, and which, like Spain and Turkey, will be impoverished if they buy them.

THE

IRON AND STEEL EXHIBITS

AT THE

UNIVERSAL EXPOSITION OF 1878,

AT PARIS.

A REPORT TO THE SECRETARY OF STATE

BY

DANIEL J. MORRELL,

UNITED STATES COMMISSIONER TO THE UNIVERSAL EXPOSITION OF 1878.

PRINTED BY PERMISSION OF THE SECRETARY.

PHILADELPHIA:
THE AMERICAN IRON AND STEEL ASSOCIATION,
No. 265 SOUTH FOURTH STREET.
1879.